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ABSTRACT

This report compares similarities and differences in water pollution as it is presented in selected curriculum materials. The materials selected for analysis included materials from five projects in the United States, England, Israel, and West Germany. Each set of instructional materials is analyzed including the framework of the units, selection of the content, composition of teacher's guides, composition of student texts, student activities and methods, and use of media. The report concludes with recommendations based on data obtained in the study. (SB)

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IPN Institut für die Pädagogik der Naturwissenschaften
an der Christian-Albrechts-Universität Kiel

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WATER POLLUTION IN ENVIRONMENTAL EDUCATION CURRICULA

A Comparative Study

1978

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an der Christian-Albrechts-Universität Kiel

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FOREWORD

The author of this work report took part in discussions with IPN staff members two years ago. Several ecological projects came up during these discussions. Abraham Blum pointed out various interesting parallels and divergencies in the ecological projects of different countries. He offered to elaborate in writing on the comparisons he did in the course of his studies.

The evaluation of the IPN curriculum in this comparison turned out to be relatively positive. This is why we at first hesitated about publishing the investigation. Because of the itensification of international discussion about environmental education, we now think that the comparison of instruction units might be relevant for various interested parties. We are, therefore, publishing the paper as a work report.

Karl Frey

Chapter 1

ENVIRONMENTAL EDUCATION CURRICULA - WORLDWIDE

1.1. Definitions

'Environmental education' and 'curriculum' are terms, which are interpreted in so many ways that it is not surprising to find the compounded term 'environmental education curriculum' being used to mean nearly every good thing in education. Therefore, some limitations and definitions are needed.

By a curriculum unit we mean, in this context, a detailed and sequential syllabus with supporting materials for students and teachers, prepared with the intention to be used in many schools. Such a unit could be a prominent chapter in a wider school curriculum or an independent, self-contained unit which can be built into various frameworks.

The term environmental education can be used in a maximalistic sense as adopted, for instance, by a project which calls itself Total Education in the Total Environment (LOCKARD, 1974, p.385). Most other environmental education projects would accept some limitations, at least in the scope of subjects covered by the curriculum (BLUM, 1973).

The International Union for the Conservation of Nature and Natural Resources (IUCNN) accepted at their 1970 meeting in Nevada the following definition for environmental education:

> "Environmental education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among man, his culture and his biophysical surroundings. Environmental education also entails practice in decision-making and self-formulating of the code of behaviour about issues concerning environmental quality".

At about the same time the United States Environmental Act of 1970 became law and enabled the funding of many projects on the

local and the State level. Its definition of environmental education includes also a position statement on the topics which might be treated in environmental education programmes:

> "...The term 'environmental education' means the educational process dealing with man's relationship with his natural and man-made surroundings, and includes the relation of population, pollution, resource allocation and depletion, conservation, transportation, technology, and urban and rural planning to the total human environment."
> (cited in MORRISETT and WILEY, 1971)

Here pollution is explicitly stated as one of the major issues in environmental education.

In this study we are concerned mainly with water pollution in environmental education curricula. This specific topic was suggested by IUCNN for both middle and secondary schools. The relevant objectives were clad by IUCNN educators into behavioural terms:

> "Middle School (11 - 14 years)
> Water: ... (The student) has an idea of influence of water in the distribution of biological communities and how the distribution can be disturbed by pollution ...
>
> Secondary School (15 - 18 years)
> Water: ... (The student) analyzes and contributes to the decisions affecting the availability and quality of water."
> (cited in ENVIRONMENTAL EDUCATION, 1972/73)

The authors of these objectives believe in a spiral curriculum (BRUNER, 1960), which aims at first to create awareness (see KRATHWOHL et al, 1964) and then to build up the knowledge, attitudes and skills needed to participate in the decision making process concerning water pollution.

For our present purpose, the comparison of Problems of Water Pollution (Trial Version, 1976) with other curriculum units on this topic, the all embracing term 'environmental education' will be limited to the use of water pollution problem to lead students to an understanding of the nature of the problem and its possible causes, and to develop their skills and willingness to help implement an optimal solution.

1.2. Sources

So far there is no world-wide index of environmental education curricula. In the United States the Science, Mathematics and Environmental Education Information Analysis Center (SMEAC), located at Ohio State University as part of the national ERIC educational research information system, compiles two directories which are periodically updated:

1. Directory of Projects and Programs in Environmental Education for Elementary and Secondary Schools.

   The editors are John F. Disinger and Beverly M. Lee. The 4th edition was published 1976. It contains detailed descriptions of over 200 environmental education projects and programmes recommended by state coordinators for environmental education. Most of the these projects have a local character and many were produced by and for local teachers, with the help of federal and state funds. The directory does not give any indication on the quality of the materials. Its format was modeled after the Report of the International Clearinghouse on Science and Methematics Curricular Activities (LOCKARD, 1974) described later in this chapter.

2. Environmental Education 1975: A State by State Report

   A quantitatively even more comprehensive but non-selective directory, also compiled by ERIC/SMEAC, in cooperation with the Office of Enviromental Education in the US Office of Education. Its preparation was based on a five volume set of State Directories in Environmental Education. It contains not only environmental curricula, but also all kind of documents released by the various state education authorities.

Up-to-date information is published in the ERIC/SEMEAC Information Bulletin: Environment, published by the ERIC/SMEAC Clearinghouse at Ohio State University, Columbus, Ohio.

The only international directory, which includes environmental programmes, is the

> Report of the International Clearinghouse for Science and Mathematics Curricular Activities,

which is edited by David Lockard at the Science Teaching Center, University of Maryland. Although this Clearinghouse Report, as it

is usually referred to, lists also a few social science projects, these are the exception. The bulk of the reports come from natural science programmes.

In the 9th Clearinghouse Report (LOCKARD, 1974) the main subject area index was enlarged to include among 56 subjects also environmental education, ecology, marine and nautical science, and water resource management. Ecology appears only twice and the last three categories only once in the categorisation of projects. In the 1974 report, which lists the curriculum projects developed between 1956 - 1974, which were known to the Clearinghouse, 35 projects mentioned environmental education (or one of the four more detailed areas) as one of their subject areas. 29 of these projects were American (and partly covered also by the ERIC/SMEAC directory), the others came from Asia (2), Australia (1) and from different pacific territories. The non-American projects catalogued as environmental were:

Agriculture as Environmental Education (AES), Israel .
Integrated Science Curriculum Project, Japan.
Victorian Primary Schools' Science Course, Australia.
Environmental Education for Guam Schools Project (EEGSP), Guam.
Britisch Solomon Islands Primary Science (SIEAS), British Solomon Islands.
Samoan Sea Study Laboratories (SSSL), Samoa.

The Guam project is the only one in the Clearinghouse Report, which is explicitly listed as 'ecological', although certainly more curricula concentrate on ecological subjects. It appears that the other ecological programmes prefered to emphasize biology as the larger content concept.

Out of the six non-American environmental projects only the Samoan programme mentions water pollution specifically as topic.

The Clearinghouse Report is a directory and not a list of recommend curricula. In the 9th report, unlike earlier ones, major projects are allocated the same space as local show-offs. (For instance

one man working part-time declares that he prepares 'curricula for all age and ability groups').

In as far as the details given in the report allow an evaluation how significant the American projects are, the following breakdown was found:

11 local projects - usually for a school district or a local environmental centre;

7 country projects - some of which are considered for recommendation at the state level;

5 state projects - partly in a very specialized field (e.g. "environmental impact of electrical power generation");

3 national projects, which will be discussed here in brief;

3 minor or new projects, the possible impact of which is not (yet) clear.

The three American projects with a nation-wide scope, which indidated 'environmental' as one of their subject areas, were:

Me And My Environment (MAME), prepared by the Biological Science Curriculum Study (BSCS),

Man And The Environment (MATE), prepared by the Educational Research Council (ERC) of America,

Enviromental Education Guide Series, prepared by the Institute of Enviromental Education (IEE) and quoted under Cuyahuga Heritage Project, Ohio.

The water pollution chapters of Man and the Environment will be discussed further in the present study.

The 'Curriculum Activities Guide to Water Pollution and Environmental Studies' (Draft 1971), developed by the Institute for Environmental Education, contains in two volumes many resources and suggestions for activities, but -

> "The activities ... should not be considered as a self-contained curriculum ... The guide is not arranged in any planned sequential order".
> (Draft 1971, p. XII)

Therefore, this activities guide did not fit the definition of a curriculum as used in this study (see section 1.1.) and will not be discussed here.

Me and My Environment is the BSCS programme for the Educable Mentally Handicapped. In this programme 'environmental' means anything with which 'Me' comes into contact. It is not concerned with ecological issues.

Some projects use the term 'environmental' in their title, but not as subject areas. The most prominent among them, the Environmental Studies (ES) project, mentions not less than ten subject areas with which it is concerned, but not 'environmental'. This project grew out of the Earth Science Curriculum Project (ESCP) of the American Geological Institute. It developed into one of the major exponents of the idea that 'environmental' should stand for an approach and not for a subject matter area:

> "The title 'Environmental Studies' relates primarily to the notion that the immediate environment of the students, the school, the school-ground, the community are all legitimate for study".
>
> (LOCKARD 1974, p. 270)

The Marine Social Studies Project in Hawaii, which produces the 'Shoreline Management' unit, which will be discussed in this study, is not yet reported in the 9th Clearinghouse Report because it is a fairly recent development.

In England and Wales curriculum development on a national or regional level is not guided, it is supported mainly by the Schools Council, but also by private foundations. The Council's pamphlet 'Learning and Teaching Schemes in Environmental Education' (SCHOOLS COUNCIL, 1976) lists 27 Schools Council curriculum projects which -

> "... contribute to environmental education. Some projects are totally concerned with this field, some just touch on it in a number of ways."

This 'touch' can be quite peripheral, e.g. in Mathematics for the Majority Continuation Project or in Local Radio as a Means of Disseminating Pupils' Programmes and In-Serive Teacher Education. Nearly all the major Nuffield and Schools Council subject curricula in science, social studies and humanities are listed as having some environmental connotation.

The projects mainly concerned with environmental education are:

1. Environmental Studies (5/13)
   The main aim of the project was to help teachers use the local environment to provide experiences that help a child develop a series of skills and concepts. This is done in the form of teachers' guides, which use mainly case studies and emphasize geological and geographical-historical aspects of the environment.

2. Project Environment
   This project, which aims at the 8-18 years range, has attempted to build on the long Rural Studies tradition in schools, according to which students learned to enjoy the local environment and to care for living organisms. While the scope of rural studies was usually restricted to the school garden, Project Environment suggests to use the surroundings of the school and trails as outdoor resources.

Among the 27 projects listed in the Schools Council pamphlet none has developed a specific unit of water pollution. The one project which did just that, the Conservation Education Project, is not listed because it was not funded by the Schools Council.

The development of modern curricula with students and teachers materials advocating an enquiry approach started on the European mainland later that in the English speaking countries and was strongly influenced by the latter. The leading institution was the Institute for Science Education (Institut für die Pädagogik der Naturwissenschaften IPN) in Kiel, Western Germany. Again comparing only quantitatively, the 9th Clearinghouse Report lists 56 British

and 30 continental European projects. Among the latter 13 are German projects, 8 of them developed at the IPN.

The major German project with a detailed curriculum unit on water pollution is IPN's "Problems of Water Pollution". This project can be seen as a forerunner of a larger effort to develop a new approach to the whole field of ecological education.

A smaller project - 'Endagering the Environment - Exemplified by a River Investigation' - was prepared by a group of biology teachers in an In-Service course at the HESSISCHES INSTITUT FÜR LEHRERFORTBILDUNG (1976) and has the sub-title 'Elements of a Teaching Unit'. This project too does not fit into the limitations imposed on the term 'curriculum' in this study.

The number of projects listed in the International Clearinghouse Report in any one country does not give any indication on their quality. But it can serve as hint to the curricular activity going on in that country, even if one takes in account that to be listed in the Clearinghouse Report indicates only the project director's interest or acquiescence to let others know about the existence of his project.

Ranking the countries covered by the Clearinghouse Report of 1974 according to the number of projects, one finds after the United States (200) and Britain (56) the Federal Republic, Australia, Israel, India and Japan with 10-13 projects each.

It is perhaps not surprising to find that Israel, being a melting pot of different cultural trends, situated geographically and economically between the developed and the under-developed nations and having a long tradition of learning, should have developed the largest number of modern curriculum projects relative to the number of inhabitants.

The topic of water pollution is dealt with intensively by the Israeli 'Man and Water' unit, prepared by the Biology for Junior Secondary Schools project at Haifa University and the Curriculum Centre of the Ministry of Education and Culture. (This project is listed in the 8th, but not in the 9th Clearinghouse Report). A more restricted chapter on the nitrate pollution of drinking water is included in the 'Let's Grow Plants' unit (BLUM, 1971) of the Agriculture as Environmental Science project (LOCKARD, 1974).

1.3. Selection of the Projects for this Analysis

A number of criteria were used in the selection of the curricula, to which the IPN unit on water pollution was to be compared. It was felt that the chosen curricla should be major projects developed at a national level or aimed at reaching a wide target population; that they should represent on the one hand the curricular thinking in their own country and, on the other hand, the diversity of approaches typical for environmental education and curriculum development.

In spite of the fast growing amount of modern school curricula using an inquiry approach generally, and of programmes in environmental education specifically, very little has been published about the deliberations which brought about major decisions in the development of these curricula.

Curriculum Projects are usually hard pressed for 'output'. This constraint is usually stronger when the project is operated in a government department, which is pledged to have the new curriculum ready at a certain date. But also when funding comes from scientific foundations it is restricted to a period which is short enough to press curriculum developers to give first priority to the production of students and teachers materials, then to evaluation and only in rare cases the history of the curriculum is documented. Therefore, a further criterion for the selection of the water pollution curricula for the present study was the availability of the history of the projects or the familiarity of the author with the project teams, so that inside information could be obtained when needed.

Based on these criteria five major curricula for secondary school students from four countries were chosen for this study:

(1) Problems of Water Pollution, developed at the Institut für die Pädagogik der Naturwissenschaften (IPN) at Kiel University (project director: Günter Eulefeld). It was planned for the 8th to 10th school year, with a strong emphasis on work in groups of students, who investigate different topics. The project tries to cross the barrier between subject matter fields.

(2) Sink or Swim, one of three units in the serie People and Resources, which was prepared by the Conservation Education Project (director: Peter Kelly) at the Centre for Science Education, Chelsea College, University of London. The materials (written mainly by John A. Barker) are aimed at a wide age range of secondary students. In this project too an integrated approach is taken.

(3) Man and Water is a central unit in the Israeli 9th grade biology curriculum. It was developed by a team (director: Miriam Ben Peretz) at the School of Education, Haifa University, for the Junior Secondary Biology Project (director: Moshe Silberstein) of the Curriculum Centre, Ministry of Education and Culture, Jerusalem.

(4) Is Lake Erie Dead and What Is the Price of Progress? (on thermal pollution of rivers and lakes) are two major 'investigations' in Man and the Environment, an introductory life science programme for grade 7. It was developed at the Educational Research Council (ERC) of America, Cleveland, Ohio and written by Frederick A. Rasmussen, (Coordinator), Paul Holobinko and Victor M. Showalter (who served also as director of science at ERC).

(5) Shoreline Management, the first course of the Marine Social Studies Project in Hawaii (directors: Ronald L. Mitchell and Francis M. Pottenger), is a new type of environmental

programme, in which elements from various social sciences and local cultural heritage are integrated. It is aimed at senior high school students (grades 10-12).

Out of these curricula only Man and the Environment was categorized as 'environmental' in the 9th Clearinghouse Report. The others were either still in an early stage of development and therefore not yet reported, or part of a larger science project, which did not bother to add 'environmental' to their description of the subject areas treated.

1.4. Summary

Before suitable curricula could be chosen for the present, comparative study, the terms 'environmental education' and 'curriculum' had first to be defined. Since these terms are being used in practice in very different ways, restrictive definitions were used.

An investigation of the reports of the International Clearinghouse, in which science education curricula are listed worldwide, showed that this uncritical volume could give only a partial picture of what is going on in the field of science education curriculum development. Also national lists of environmental education programmes proved to be either uncritical or incomplete. After the criteria for the choice of the projects for the present study had been fixed, five different projects from four countries were selected, each of which could be assumed to be typical for the current curriculum thinking at its place of origin.

Chapter 2

CHOOSING THE CENTRAL ISSUE FOR AN ENVIRONMENTAL EDUCATION CURRICULUM

2.1. Factors Influencing the Choice

According to the generally accepted definitions environmental education is not solely descriptive. To fulfill its basic aim of leading to conservation and students' involvement in the improvement of the environment it has to be prescriptive and should deal with real issues or problems. Therefore environmental curricula take usually a problem-centred approach to teaching and water pollution is one of the possible choices. Before analyzing why the different curricula under review have taken this choice, we shall first look at various criteria which can be used to select a central pollution problem as focal point of an environmental curriculum unit.

Four such criteria are prominent (BLUM, 1977):

> "(a) Importance or urgency from the point of view of environmental monitoring;
>
> (b) Appeal to students and their ability to cope with the issue;
>
> (c) Expertise available to the planners;
>
> (d) Relation to the over-all educational planning.
>
> With each criterion a particular group of people will tend to have a more dominant influence than others. In the first, mainly environmental subject matter specialists will be consulted. The second criterion is clearly student-centred, the third teacher-centred and the fourth is particularly relevant in educational systems with a high degree of educational planning".

No doubt, priority should be given to those environmental issues, which are deemed to be the most serious or urgent. This is a theoretical truismm which in most cases cannot be translated into practice because there is no way how to assess the seriousness and the urgency of a problem empirically and objectively. Monitoring specialists are reluctant to stick out their necks on this question. At the most they could estimate potential economic losses

(e.g. fish in a lake threatened by pollution, or loss of fertility, when land is eroded). Such estimates depend on a lot of subjective assumptions, on educated guesses (with an emphasis on the noun), on the frame of reference, in which the question is posed and on many more unquantifyable factors. Therefore so many test cases fail in court because the expert testimonies introduced by the parties clash with each other.

This state of affairs exists even when economics factors, which can be expressed in monetary units, are at stake. How much more inexact and fragile are expert opinions on the "worth" of a species threatened by extinction or the value of an undisturbed nature reserve?

Yet there are cases when an environmental problem is felt to be so central that it is given also educational priority. Such a case will be discussed later in this chapter.

The appeal a topic has to students is given varying weight, when curriculum workers decide on the central topic of a unit. Students can be motivated by the content of the central theme, by the method of investigation used, or by the meaningfulness of the results.

These factors can combine synergistically to set the stage for a peak learning experience, but they don't do so automatically. A topic might be attractive, but the necessary methods of investigation might be neither suitable nor adaptable to the given school situation. For instance, when the Agriculture as Environmental Science project wanted to treat the problem of high nitrate concentrations in drinking water and discuss some problems connected with Haeminoglobinemia in 'blue babies', the curriculum developers found that the topic itself could be interesting to students, but that all the nitrate measurements are based on colorimetric methods, which were economically not feasible. Therefore, another approach to nitrate pollution of drinking water had to be developed. No actual measurements were to be taken by students and the emphasis shifted to the

interpretation of data and to looking for the 'real villain' mainly responsible for 'blue babies' - in this case the habit of feeding babies with milk powder dissolved in water.

When students get the feeling that their investigation was of scientific and/or pratical value, their motivation can be considerably boosted. Sometimes quite young children can pool their observations and measurements, when the survey is monitored by a researcher and when it can be shown that the data collection by students was meaningful.

A good example for this is the water pollution survey made in summer 1971 by children in Great Britain. It started with an article on water pollution, which appeared in the colour supplement of The Sunday Times. Children were encouraged to obtain for a small fee a "Clean Water Kit" with which they could estimate stream water pollution in their vicinity. Within a short time 10 000 kits were sold and some 8000 of the children sent their reports to the Advisory Council for Education in Cambridge, where the data were analyzed. This work was done during the summer holidays and therefore no teacher supervision or direction was possible. Most of the Children participating in the survey were aged 8-15 and apparently had no difficulties in understanding the broadsheet, on which the indicator organisms and the water tests were described. The researcher who analyzed the reports (MELLENBY, 1974) compared the results from some counties with data obtained by the river authorities. There were no major discrepancies between the data obtained by the children and those of the experts. In some cases children identified so far unknown local sources of pollution.

In this survey children were not only motivated. The quite accurate data they reported show that in spite of their young age and lack of experience the children had made careful observations and gave more details than had previously been recorded for many areas.

A similar water pollution survey was reported by HODGKISS (1973) who had used 8745 investigations by Hong Kong secondary school students, aged 11-15, on the presence or absence of 20 biological indicators orgnisms in the streams of Hong Kong to draw detailed water pollution maps. This survey covered a third of Hong Kong's total land area, a project which otherwise would have needed considerable manpower. In this case students took part in an original survey and did not repeat measurements made previously by experts. In this survey too students worked with photographs and descriptions. but under the direction of teachers who had received some training from the principal investigator and his assistants. Each contributing student received a copy of the research report, in which the common effort was summarized.

After the success of the water pollution surveys in Britain and Hong Kong also air pollution surveys were made by students in both countries. In spite of the higher price of the Clean Air Research Pack, 15 000 children bought it, after an article had appeared in the colour supplement of The Sunday Times. Again valid and meaningful results were reported (GILBERT, 1974), and for the first time Scotland too was covered. In this air pollution survey the percentage of students returning the survey form was much lower than in the water pollution survey, only 10% out of the 15 000 who had bought the kit (and so shown interest). Two possible explanations could be that the identification of lichens is more difficult than that of aquatic indicator organisms or that working with animals is more attractive to children than with lichens.

Similar student involvement in environmental surveys were reported from Japan (BIOSPHERA, 1976), where 5000 secondary students surveyed the effect of photochemical oxydants on different species of mourning glory and the value of these plants for monitoring purposes.

Also junior secondary students in Hawaii, who studied the air pollution unit of the Foundational Approach to Science Teaching project (LOCKARD, 1974, p. 276) were engaged in a state wide air pollution survey. Student monitoring stations are on all islands, in all communities. Many of these communities are not seperately monitored by the State (POTTENGER, 1977).

The main task of the leader of a curriculum development group is to balance the deliberations between experts on the subject matter, teachers and others who pool their expert knowledge. It is the leader's task to balance the influence of the subject matter specialist, who is usually no expert in pedagogics or child psychology and may be without experience in teaching, with the impact of the educators in the team, who naturally have less knowledge of the subject matter field discussed.

Often the respect an eminent scientist commands, puts him into the most influential role in choosing the topic for an environmental curriculum unit. The other partners of the team believe that their main difficulty will be to devise workable investigations and for that they depend on the subject matter expert. They may also held the belief that the content of the unit is less important than the method and therefore the choice of topic can be left to a large degree to the man who is expected to know most about the content - the environmental scientist.

Sometimes it is difficult to find research workers who are enthusiastic about curriculum development at the secondary level. Specially when the scientists work in 'publish or perish' institutions, in which teaching is less highly regarded than research, they might be reluctant to 'waste time' on the development of curricular materials for the below tertiary level. In such a case the curriculum decisions makers might be forced to choose the topic for which expert help is readily available.

The IPN unit Problems of Water Pollution will serve as an example for a curriculum development, in which the choice of topic was strongly influenced by subject matter considerations, but also in others, like Man and Water and Shoreline Management, the subject matter specialists played a central role.

Some countries have quite centralized educational systems, in which major curriculum decisions are made at a national level (e.g. in France and in the Soviet Block) while others have no compulsory

curriculum and only few minimum requirements (e.g. England and most of the US States). At least officially individual schools in England can teach what they want. Only physical and religious education are required. Yet in practice the Examination Boards have a tremendous influence on the school's curriculum decisions. Lately voices demanding a minimal core curriculum have become louder.

In the United States regulations vary from state to state, but nation-wide schools are influenced strongly in their curriculum decisions by major curriculum projects and text book publishers.

Where countries have a federal structure, education is usually left to the main constituents of the federation (the States in the US and in Australia, the Laender in the German Federal Republic and the Cantons in the Swiss Confederation). These adopt often quite varied educational systems, but the trend seems to be towards more unified curricula.

In Israel and many developing countries curriculum planning is done by national curriculum centres, which are asked to implement central educational policy decisions and which are perhaps more than others aware of national issues, as we shall see when analyzing the development of Man and Water.

Due to its history and to its insular character, Hawaii is probably the most centralistic state in the United States. Its curriculum development is planned state-wide and is influenced strongly by polical decisions of the state's Department of Education. This is also true for environmental education. Like other Amercian states Hawaii enacted a bill, the purpose of which is: -

> "... to enrich the understanding of the ecological systems and natural resources important to the people of Hawaii".

This was then translated into policy decisions by the DEPARTMENT OF EDUCATION (1970). The growing awareness of the central role which the ocean plays in the life of its people, influenced the decision to introduce marine education as focus of environmental education.

Within this centralistic framework developed various curriculum projects, i.a. the highly coordinated Marine Studies Projects (one in Social Studies and one in Science). The influence which over-all planning had on the choice of Kaneohe bay (which suffers from serious water pollution) as case study will be shown in more details later in this chapter.

It is seldom that only one of the four criteria - importance, appeal to students, expert advice available or over-all planning - account for the choice of topic in an enrionmental education programme. Sometines all four play a decisive role, as was the case in the curriculum unit The Fly, DDT and We (BLUM, 1974) which was developed the Curriculum Centre of the Ministary of Education in Israel as part of a national curriculum planning effort. The pesticide problem was chosen as important for two reasons: Israelis have, on the average, one of the highest DDT 'content' in the world - 19 ppm. On the other hand Israel's main agricultural export crop, Citrus, suffers from pests, especially the Mediterranean Fruit Fly, a pest which cannot be controlled solely by biological methods. There is , then, a real problem for both consumers and producers.

The project team, looking for professional expertise, approached the Biological Control Institute of the Israel Citrus Marketing Board, probably the largest institute of its kind after that of the University of California. The researchers there were not only ready to serve as scientific and technical advisers, they agreed also to supply schools with eggs and pupae of the pest and of two natural enemies introduced recently into the country. The possibility of supplying these living organisms made implementation of the programme much more feasible. At the same time,

through this contact between the project team and the research institute, the usually long time it takes for scientific discoveries to reach schools could be shortened. Although work on the introduction of the two pest parasites was only in a pilot stage and not yet used commercially by citrus growers, students learned about the problems of biological control with the help of on-going research. Their being close to the 'frontier of science' added much to students' interests. Some of them felt somewhat naively that by their experiments they would help to solve an economic problem of the farming community. The topic chosen had also another aspect, which usually appeals to students. Earlier work had shown that most of the students are more interested in learning about animals than on plants. Choosing an animal of economic importance could enhance their motivation (BLUM, 1976).

2.2. The Choice of Water Pollution as Central Issue by the Projects Under Review

2.2.1. In 'Problems of Water Pollution'.

The initiator of this unit (EULEFELD, 1973) had three goals in mind, when he choose the oxygen-content of water as central topic for the first unit of an environmental education programme. These goals were:

(a) Students should be able to plan and execute a partial ecological analysis.

(b) They should have a chance to explore the results of human interference with the environment.

(c) Working in groups, students should be able to find out how environmental problems arose and how they can be solved.

In order to translate these goals into curricular activities some conditions habe to be met(ibid.):

(a) The experimental effort should be small enough to enable the experiment to remain a means without becoming the objective.

(b) The issue chosen should be of special importance to Man's environment.

(c) Suitable materials and equipment should be available.

In each of the goal statements and the corresponding statements of conditions, one of the criteria for choosing a topic (BLUM, 1977) is prominent: In the first - over-all education objectives, in the second - the environmental importance of the topic, in the third - the subject matter expertise. All three goal statements emphasize the students' role in the learning process but do not imply explicitly the affective criterion of arousing students' interest in the topic.

For several reasons water as ecosystem with pollution problems was prefered to a terrestrial ecosystem or air pollution. (EULEFELD, 1976). Geographically, water biotopes differ less than land biotopes. This was important because the Problems of Water Pollution unit was expected to be considered for adaptation by educators in all German Laender. Students come into more conscious contact with water than with air and contribute to water pollution, but usally not to air pollution.

"Oxygen-content of water and its dependence on biotic and abiotic factors as temperature, light, green plants, animals, bacteria, household sewage and poisons"

was chosen as more central theme (EULEFELD, 1975). The reasons given for this choice were:

(a) The public is conscious of the importance of oxygen-content as central indicator for water quality.

(b) Model experiments of single factors in aquaria can be made in each school.

(c) Drastic situations, as the death of fish after the water has been polluted by oxygen-consuming materials, can be used to trigger off a discussion and experiments.

While the first argument can be doubted in good faith and the third is not persuasive, because dramatic situations can be found for all major pollution problems, the flexibility of experiments for classroom use is a major curriculum consideration. As we shall see also other ecological curriculum project teams discussed the advantages and disadvantages of the use of aquaria.

Fortunately standard techniques were readily available for oxygen content analysis (EULEFELD, 1974). Articles by SCHMITZ (1969) on biological and chemical criteria for the evaluation of water quality and suggestions by various scientists how to use chemical methods and bio-indicators in schools were decisive in choosing oxygen content in water as starting point. A commercially available test-kit, which was already tried out, could be used as 'black box' by students who had no chemical knowledge (EULEFELD, 1973). This kit uses prepacked portions of chemicals and normed instruments, which are used as in a recipe and therefore can be handled by 13-14 year old students without chemical knowledge. One of the disadvantages is the price of the kit, but this seems not to have been a deterrent in the case of Problems of Water Pollution. Later a cheaper kit was developed by another company.

Research workers at the Max-Planck-Institute for Limnology in Plön were happy to cooperate in the adaption of their methods to the school situation. First three biological themes were planned: experiments on the oxygen turn-over in water, on indicator organisms in flowing waters and on microscopic investigations. The latter had to be abandoned because it proved to be too difficult for 8th grade students.

During a pre-trial stage it was found that students wanted to investigate the water in their community and were also interested in the social aspects of the water pollution problem. This led to the formation of an interdisciplinary team which developed two themes with an emphasis on sociological, economical and political aspects:

"What effort does our community make to keep the water clean?" and "Polluters and those who suffer from the pollution - how do people in our community look at the water situation?"

2.2.2. In 'Man and Water'

Although some of the topics (and especially the pollution of streams) and relevant activities in this Isreali unit are the same as in Problems of Water Pollution, and for similar reasons, the process of decision making was quite different.

While Problems of Water Pollution was conceived from the beginning as a modular unit, which could be fitted by teachers into any programme, Man and Water was developed as part of the compulsory 9th grade biology curriculum and in the wider framework of a national three-year curriculum for junior high schools (see section 2.3.).

One of the 9th grade topics, according to the basic curriculum guidelines, was to be "Man and Water".

At a Workshop in which the development team and scientists interested in this theme and in education participated, the thematic core of Man in Nature was to be mapped. Participants were asked to suggest major topics, but also possible sources, activities and illustrations.

At that meeting (PROTOCOLS, 1971) statements centred on criteria for the choice of the issue and of specific topics. The pieces of advice given to the team by various participants were:

To go from a general overview to specific problems.
To show the various aspects of controversial problems and not to preach.
To use indiginous and real problems.
To educate towards good citizenship.
To show how science works.
To let students collect evidence.
To use simulations.
To go out on field trips.

Also suggestions for topics varied, often according to the expertise of the exponent:

1. Water, as good teaching model for cycles and equilibrium.
2. Pollution of the sea and the shore, with a special chapter on Lake Kinneret and River Jordan.
3. Drainage of the Hule swamps.
4. Inclusion of a chemical problem in agriculture, soil fertility.
5. Pesticides.
6. Growth of air pollution bioindicators.
7. Adaptation.
8. Van Potter's principles.
9. Man in an urban environment.
10. Population growth, economic growth and the distribution of resources.
11. The actions of various population groups to prevent specific development projects which would make air or water pollution worse and would destroy nature reserves.

Some of these themeswere mentioned a few times in the discussion. This ended in a summary by the chairman, suggesting 7 practical teaching units - one of which was to be:

> "Lake Kineret and River Jordan as the main water reservoir (of the country) and as lake with all the social, economic, industrial and health implication".

The other units suggested were to be: Concepts in the conservation of the environment and of nature, cycles in nature, the positive and negative use of (synthetic) materials by man (textiles, medications), urbanization, man's place in the biosphere and the meaning of ecological equilibrium.

The project team choose to concentrate first on 'Man and Water' for the following reasons:

"1. The water problem is one of the basic problems of the country.
2. Problems of water supply were handled by man vigourously in many countries, including our own. This was done already in ancient times, but even more lately. Therefore, this topic can be used to show Man's ability to improve the quality of his environment.

3. An investigation of water quality creates educational opportunities to foster an objective scientific attitude by expressing the indications of pollution quantitatively.

4. In this topic it is relatively easy to create an 'ecosystem' in the classroom and to show the effect of various pollutants in a most concrete fashion.

5. In the realm of water quality conservation the individual can be activated, and here lies the educational importance of the topic:

   "Demand first from yourself!"

   (Teacher's Guide p. 8)

At the time the topic was developed, a heated discussion went on, in conservation circles and over the media, on 'Dying Lake Kineret' (Israel's "Lake Erie") and therefore a case study on Lake Kineret was envisaged as model for an investigation which then could (and should) be adapted by teachers to investigate local water problems or different pollution problems, e.g. air or solid waste pollution. The Lake Kineret controversy seemed suitable because it could be used to introduce environmental issues like water recycling, polluted irrigation waters, effects of fertilizers, swamp reclamation and its effects on nitrate and phosphate balances, regional planning, deviation of salt water sources and many more generalizable issues.

During the detailled planning stage a more systematic approach became prevalent: 'Man and Water' was to become one of a group of analogical units. Instead of the investigation of Lake Kineret (the water quality of which could be improved in the meantime and became less hotly debated), river investigations became more central in 'Man and Water'. They had the advantage that teachers could bring the students easier to the object of investigation and did not have to make up their own case study - a task many teachers found too difficult. Content-wise the emphasis shifted to chemical and bacteriological effects, not least because of the strong influence, by an expert of the Enviromental Engineering Laboratory at the Israel Institute of Technology who joined the development team. In this case the expert seems to have influenced the preference given to a content area perhaps more than the content dictated what expert to choose.

2.2.3. In 'Man and the Environment'

Problems in Water Pollution is a modular unit, which can be used in connection with others in an ecological or biological sequence, but was not planned as part of a coherent whole. Man and Water was developed as part of a junior high school biology course. Man and the Environment is part of an even wider, integrated life science programme, developed at the Educational Research Council of America.

This programme has four major goals (Teacher's Guide p. T 2)

> "(a) The students should demonstrate an inquiry approach to biology and be able to design and carry out simple experiments with living organisms.
>
> (b) Students should understand the interaction between living organisms and their physical environment.
>
> (c) The students should be able to separate fact from opinion in a controversial ecological problem and state what social responsibilities are involved.
>
> (d) Students should be aware of individual variation in man and other organisms and recognize the uniqueness of each living thing".

More specific objectives in behavioral terms were formulated for the vaious investigations.

The fourth unit of 'Man and the Environment', called 'Man's effect on the environment', was developed mainly with the third goal in mind. It concentrates on pollution problems, their developmental sources and possible approaches to a solution. The main topic in the unit is water pollution, focussing on the question: "Is Lake Erie dead?"

The authors believes that:

> "There is genuine cause for concern about environmental quality. However, journalists may distort the facts to call attention to a particular problem. The case of Lake Erie is a timely example of a situation in which many people have gotten very emotionally involved without understanding the real nature of the problem". (Teacher's Guide, p. 265).

This balanced attitude is typical for the 'second-generation' environmental programmes. They came after Rachel Carson's Silent Spring' (one of the outstanding and effectful but also biased journalistic masterpiece on this subject) had triggered a whole series of sometimes nearly hysterical publications for use in school. In 'Man and the Environment', as in the other projects reviewed in this study, the question-mark has relieved the exclamation mark. The plea for involvement and for action remained. Therefore, 'Man and the Enviroment' asks the further question: Can Lake Erie (and other lakes in the students' vicinity) be saved?

The topic of water pollution was chosen as the primary focus for the pollution problem for several reasons:

1. polluted water is accessible for direct experience by learners
2. water pollution was recognized as a pressing problem by the local community
3. monitoring many parameters of water pollution can be done with relatively simple equipment.
4. bodies of water are clearly defined and, thus, are "real" to unsophisticated learners
5. a large amount of data on water pollution parameters over a relatively long period of time was readily available.

(Showalter, 1977)

After students have studied the pollution of lakes by chemicals, they are confronted with the problem of "thermal pollution by the 'clean' but hot water of power stations". The discussion of thermal pollution reaches it highest peak in the atomic power plant controversy.

2.2.4. In 'Sink or Swim' ('People and Resources')

Contrary to 'Man and the Environment' and 'Man and Water', 'People and Resources' is not part of a wider biology or social studies curriculum. In line with the English tradion which leaves curriculum decisions to the teachers, the different units of 'People and Resources' which were developed by the Conservation Education

Project at Chelsea College,London, are seen as modular blocks, which could be built into a very wide range of programme. In this respect it is similar to 'Problems of Water Pollution'.

The Conservation Education Project was set up to answer the question: what can be done practically, to educate youngsters towards social concern for the environment, rational exploitation and judicious conservation of resources. The principles to be followed were established at a symposium on 'Conservation in Education' held at Chelsea College in 1971. Participants came from many walks of like, including education, science,conservation groups, industry politics and religion.

Two major aims were to direct the selection and development of the content.

> "a. To provide information and experience by which students would gain appreciation of some of the diverse ways in which people both affect and are affected by the use of natural resources.
>
> b. To provide experiences of both the science and art of making decisions concerned with the balance between environment, exploitation and human needs"
>
> (Teacher's Guide, p. 7)

While the first aim is typical for most environment education programmes, the second is seldom emphasized so explicitly.

The Conservation Education Project team felt that the key principles, which were developed from the central aims

> "appeared to be applicable, to some extend, to any topic which might be considered"
>
> (Teacher's Guide, p. 7)

When choosing the content, first a systematic approach was used. Three pollution areas were envisaged: air, water and land. But then it was felt that pollution on the land was a much less straight forward matter than in the air and water. In the end a curriculum unit was created on topics like Food, Population growth, Natural Resources and Energy. These are dealt with in the booklet 'In the balance'. The other parts of People and Resources are 'Sink or Swim?' and 'Breathing Space'.

Sink or Swim was chosen as first unit for a number of reasons. Water pollution was considered a relatively straight forward topic, with less parameters than, for instance, The Balance of Nature. It was, and is, obviously a major problem which students in most parts of Britain could study, using their own environment. For this purpose a vast array of activities could be adapted from existing sources and, if need be, developed without the need for too sophisticated apparatus.

There was also a further motivational factor which was influential at the time. In conncetion with the European Conservation Year an article on water pollution appeared in the colour supplement of The Sunday Times, together with the information that a 'kit' to study the subject could be obtained, on the payment of 75 pence. Approximately 10,000 'clean water kits' were distributed by the Advisory Centre for Education at Cambridge and some 8,000 children returned reports on the water situation in their locality (MELLANBY, 1974).

2.2.5. In "Shoreline Management"

This programme is very different from all the others mentioned so far. Chapters are not developed according to topic areas, but rather round different approaches (historical, geographical, folkloric, model building etc.). These approaches represent mainly the Social Sciences, but also use is made of investigational skills, which students might have acquired in their natural science studies.

More than any other of the projects under review, 'Shoreline Management' was developed on the basis of long debated policy decisions, taken at various levels by Governmental and public advisory bodies.

Topic-wise (and incidentally also institution-wise) two main influences were at work: on one hand the environmental wave, in which many politicians were involved and which affected also educational legislation and policy making, and on the other hand the attempts of teachers and scientists to introduce Marine Education into this insular State's curriculum.

The DEPARTMENT OF EDUCATION (1970) was expected

> "to provide learning experience in environment studies, relating to man's relationship to his environment and to his efforts to understand and control it. Such learning experiences shall be included in concepts commonly taught in science, geography, economics, applied mathematics, physical education, practical arts and vocational education".

Furthermore:

> "The academic programme shall include a desirable mix of appropriate and comprehensive learning activities in the area of (a) communications (b) humanities and (c) environmental studies".

For this latter purpose an Environmental Education Task Force Committee was set up consisting of members of the University of Hawaii Curriculum Research Development Group and representatives of the Office of Instructional Services and the District Offices of the Department of Education.

In the introduction to 'Environmental Education in Hawaii', the rationale of the DEPARTMENT OF EDUCATION (1977),the State's pride on its environmental legislation shines through:

> "the awareness of Hawaii's special ecological problems has resulted in some far-sighted environmental initiatives. Snakes have been effectively excluded... Rabies has also been excluded... Hawaii was the first state to develop state land use regulations, and the watersheds have been protected to produce one of the world's purest water supplies. The visual pollution of unregulated billboards and advertising has long been controlled to help Hawaii avoid developing a Las Vegas-like appearance".

The rationale then goes on to mention some environmental problems, which have not yet been controlled, giving as example:

> "Kaneohe Bay has had its ecology system substantially altered in the last few decades, through sewage and top-soil run off".

The solution is seen in planning and -

> "such planning is inextricably tied to public knowledge and public concern. Unsolved problem areas include: land management, ocean and shoreline management..."

Rather than stress the negative results of pollution, the positive side of planning is put in the foreground:

> "Even in the face of pressing environmental concerns, the emphasis of the programme for schools focus on positive aspects of study, including our capacities to seek and generate new knowledge, ... and to plan and execute effective environmental management programmes while retaining sight of the aesthetic qualities and recreational delights available in our immediate environment".

The latter condition, so typical for the Hawaiian trend of thought and feeling, is stated also as first in the list of objectives, which students should develop:

> "an awareness of the grandeur, delicacy and beauty of the world in which we live". (The Science partners had phrased their first objective less passionate, as "awareness of the holism of life, sea, land and atmosphere").

The second force (besides the general environmental trend) which influenced the choice of "Shoreline Management" and the case study of Kaneohe Bay as central curriculum topic, was the HAWAII MARINE EDUCATION COUNCIL (1975), led by the University of Hawaii scientists and educationalists, which built on earlier efforts of teachers interested in Marine Science Education. The Council first surveyed the status of the teaching of marine related subjects within the school system and found, that in spite of the insular character of the state, marine topics are taught only in a few high schools and that schools were reluctant to take their students to field trips to the ocean. The Council then drew up guidelines for a K-12 Marine Education Programme, and concentrated, as first state, on the development of two highly co-ordinated high school projects: The Marine Studies Science Project and the Marine Social Studies Project. The latter choose Shoreline Management as its central topic.

"Shoreline-Management" has 3 parts. In the first, students study the relationship between man's land-based activities and their effects on the marine environement through simulating the Kaneohe Bay experience. It serves as an introduction to many complex activities on land, which could, and often do, have substantial effects on the marine environment. In the second part students look at the physical setting of the case study area and learn to visualize its geographic parameters. In the third part, past and present controversies serve as focal points, when students try to answer the question:"Why shoreline management?"

The pollution of Kaneohe Bay by sewage and silt and the resulting death of corals is not treated separately but rather as one item in a complex situation.

2.3. The Framework in which the units were developed

The curricular units on water pollution reviewed here, represent a wide range of planning strategies from the highly structured "shoreline management" in Hawaii, which is typical for a centralized education system planning all school subjects, to the highly modular "Swim or Sink" which leaves grade level and subject framework open. In between come the three programmes "Man and the Environment", "Man and Water" and "Problems in Water Pollution" which were conceived as flexible biology units, with varying degrees of intervowenness with antecedent and postcedent teaching units.

As shown already in the previous section, Hawaii's Shoreline Management is part of a state wide master plan, covering all subjects and grade levels in the educational system. Typically for such an approach, the integrative elements would be emphasized:

> "Generally, unattended in current school practices is the viewing of subjects and issues in terms of their inter-disciplinary natures. Environmental education offers a new organizational pattern which suggests a need for identifying contects in which to reassemble the pieces of existing disciplinary studies".
>
> (DEPARTMENT OF EDUCATION 1977, p. 5/6)

And as to content:

> "The content of an Environmental Education curriculum will have much in common with thematic and subject matter areas, particularly values, careers and consumer education as well as the subject areas of science, mathematics, social studies, language arts and the fine arts. What is attempted here is the drawing of a map of the domain of Environmental Education along with suggestions for methods to develop a comprehensive curriculum".
>
> (Ibird. p. 7)

The mater plan then goes on to describe what an environment is, what the pools of environmental education are and what criteria make the selection of concepts and issues possible.

These criteria are: high social value, including intellectual importance, high survival value, and appropriateness for inclusion in formal schooling. Issues chosen should be perennial or immediate and pressing, concepts should be enduring and possess a high degree of generalizability and universality. Then, using these criteria, a catalog of concepts and issues was drawn up.

In the Hawaian master plan the choice of the content is left to the various curriculum projects, which are expected to develop these materials within the general framework. Since the projects are co-ordinated by a curriculum research and development group and key people in one project are involved also in parallel or vertically close projects, a high degree of co-ordination can be achieved.

For instance the Marine Studies Science Project, which takes in account what students have learned in the elementary school HAWAII NATURE STUDY PROJECT (1976) and the junior high school FOUNDATIONAL APPROACHES TO SCIENCE TEACHING (1976), organizes its content into four areas:

- the fluid earth
- the living ocean
- technology and the ocean
- socio-cultural studies

The latter are planned to lead into Marine Social Studies, the first unit of which is "Shoreline Management".

Israel too has a centralistic school system and a national Curriculum Centre. Although this Centre is part of the Ministry of Education, which also funds the school curricula developed at the various universities, there is not much inter-disciplinary coordination. Subject matter committees are free to plan the content areas of their subject, as long as they keep to the prescribed number of weekly periods allotted. Although the Curriculum Centre runs parallel projects in most junior high school subjects, no working contact existed between the parallel biology and social science teams, when they planned their respective syllabi.

Biology for Junior Secondary Schools is organized round three aspects of ecology, each being studied in one of grades 7 - 9, when students are 13-15 years old. The 7th grade programme is called "The Animal and its Environment", in 8th grade plant ecology is studied and one of the central 9th grade themes is "Man in Nature".

9th grade in Israel is the third and last year of a junior high school cycle which was recently created as part of a major reform in the organization of the Israeli school system. 9th grade is also the last of compulsory education. Therefore the 9th grade biology programme is expected not only to round off the junior high school ecology sequence, but it is also expected to include the "minimum" of biological knowledge and understanding, which early school leavers should have, about Man as 'specific' social animal.

Within the them "Man in Nature", 3 topical areas were foreseen and suggested by Ben Perez:

a) The nerve system and forms of behaviour (including communication in the living world, learning and social organisation).

b) Patterns of adaptation to extreme conditions (including diseases and old age).

c) Problems of conservation; problems of air, water and soil pollutions; problems of city life.

(SILBERSTEIN, 1971)

The first unit to be developed in the framework of the ecological conservationist area was "Man and Water", followed by "Man and Landscape".

In spite of the long-range planning of biology teaching in Israeli secondary schools, which takes in account the elementary science curriculum being developed at the same time, the 9th grade biology units are modular in as far as the teacher is expected to choose one or two environmental units out of a larger list. At the moment "Man and Water" is the unit chosen by most schools.

"Man and the Environment" is an introductory life science course for 7th grade. The target age level is mentioned in the Clearinghouse Report (LOCKARD, 1972), but not in the Teacher's Guide. Typical for American schools, it is planned as a one year course and no assumptions were made as to the antecedents and postcedent courses.

The programme is planned for 32-36 weeks and divided into four large units. The largest is the introductory "Investigating living things", in which students develop mainly inquiry skills. Therefore the development team suggests that students without previous experience should start with this unit, which takes about 12-13 weeks to teach. But if students have already mastered investigative skills, this unit could be shortened.

The three other units emphasize an ecological view. Unit II is "The environment effects living things" and Unit III "Living things affect each other". Among these living things, Man is very prominent and the idea, that he manages the environment is emphasized through items like "Managing a lake", "A case history in managing wild life", "What happens to garbage and trash?" "How can Clarion (an imagined planet) be improved?", "The earth management game", and "the redwood controversy".

Unit IV, "Man's effect on the environment", is on Pollution. Pagewise, it is the largest unit and also in the suggested time-table it comes first (with 9-10 or more weeks) - after the introductory unit, which introduces students, who need this, into basic investigation skills.

The main topic in this unit is water pollution, focusing on the question "Is Lake Erie dead?" It is followed by a chapter on thermal water pollution.

After discussing water pollution, 'Man and the Environment' treats two more environmental issues: pest control and air pollution. Although this study is concerned mainly with water pollution, it might be interesting to look at the wider range of pollution problems dealt with in different projects. Especially in industrial

countries, air pollution seems to become a very prominent topic in environmental education programmes, as we shall see in the case of the British conservation education project 'People and Resources'. But also in a much more rural state like Hawaii much emphasis was given to air pollution in science education (see section 2.1.).

The problem of pesticide residues are much less conspicious in environmental programmes. To the best of our knowledge, no educational unit concentrating on pesticide pollution has been published in Germany, but in the unit 'Biological Equilibrium' (EULEFELD & SCHAEFER, 1974) one hour of instruction is on chemical and biological pest control. Students read a text, which is based on Rachel Carson's 'Silent Spring', learn about the classical case of the introduction of a ladybird to control woolly aphis biologically and are encouraged to collect articles on pest control.

"People and Resources" treat the topic briefly (on 6 well illustrated pages): The Potato Blight catastrophy in Ireland is used to highlight the potential danger of pests and plant diseases. Then the locust, the granary weevil (as storage pest) and the ladybirds (as useful insects) are introduced. The last part of the chapter, "Pesticides and the Environment" concentrates on DDT and its adverse effects on the environment.

Bath University and BP Educational Service, in cooperation with the British Agro-Chemicals Association, have developed the "Ridpest File" as an independent learning kit. Its four modules are: Plants in the wrong place, Potato famine, Insects at home and abroad, Help the harvest.

"Man and the Environment" devotes one of its investigations to the question "What can we do about pests?". No laboratory or field experiments are suggested.

The major curriculum unit on insecticide residues, which is based on experimentation by students seems to be "The Fly, DDT and "We" (BLUM 1974, 1976) which was developed in Israel and is offered as

option in the 9th grade curriculum in Biology and Agriculture as Environmental Studies. In this unit the Mediterranean Fruit Fly (Ceratitis capitata) serves as focal point in a unit which is planned for 20-30 lessons. Students grow this pest insect and one of its natural enemies and study their behaviour. The story of the rise and fall of DDT is used to introduce the pesticide problem and to look for better control measures. Various possibilities are investigated experimentally. The need for a balanced approach, taking in account the demands of both consumers and producers, and the danger of exaggerations are stressed.

In 'Man and the Environment', as in 'Shoreline Management' and 'Man and Water', the teachers' guide does not discuss solutions how the teacher who was trained in one subject area can cope with interdisciplinary issues. While the long term projects in Hawaii and Israel could assume that teachers would attend introductory courses, sponsored by the central education authorities and the universities involved in the project, such a widespread retraining programme could hardly be expected from 'Man and the Environment', a commercial product which was developed by a project no longer working on that theme.

The two modular units developed in Britain and Germany are well aware of the problem a teacher trained as subject matter specialist might find when teaching interdisciplinary issues. For instance, the "Teacher Information" to the IPN Unit "Problems of Water Pollution" (p. 7), starts with this problem:

> "The instructional unit "Problems of Water Pollution" falls in many respects out of the framework of the usual subject teaching. This creates problems for the specialized teachers in Biology and Social Studies (Geography) to whom this is addressed. Normally these can be solved under the existing school conditions.
>
> The planned instruction falls into the overlap area between the school subjects Biology and Social Studies (Geography). It would be especially favourable, if it will be given by Teachers combining the subjects Biology/Social Studies (Geography).Certainly, the combination of these subject matter competencies in one person is no necessary precondition for the instruction.

Also the following alternatives could be considered:

- Biology and Social Studies teachers engage in team teaching
- Biology and Social Studies teachers coordinate the instruction, but teach separately in both subjects.
- The unit is taught only in Biology. In this case the Social Studies teacher should be available to answer student questions. Teaching the unit in the frame of Social Studies would probably be unsuccessful because experience has shown that for the numerous student experiments in the science oriented part, student need all the time a biology specialist teacher to advise them".

The developers of "Problems of Water Pollution" believe (I bid.,p.7) that it would be advantageous to offer the "Problems of Water Pollution" unit in a "free period", but they refrain from going into details, because "Environmental Education is only at the beginning of its development".

Indeed only in few countries Environmental Education has become a recognized school subject and it is doubtful, if in the near future, this as other interdisciplinary topic areas will be able to push aside one or the other of the traditional disciplines.

The most integrative and modular approach is taken by the "People and Resources" team in Britain, when discussing the context for "Sink or Swim" and the other sections of that project. The teacher's guide (p. 8.) states:

> "We do not see "People and Resources" as a school subject on its own. It is a collection of materials which can be used in a variety of contexts. For example it can be used with topics already included in established school subjects such as biology, chemistry, physics, integrated science, social studies, geography, history,environmental studies etc.... In the trials we found the materials were of particular value in science courses because they provided important social and ethical dimensions to the subject and pointed to connections with other subjects."
>
> "The books can provide interdisciplinary links between subjects. In fact, the same books can be used by the same students in different school subjects. In this way they are useful for interdisciplinary studies involving a team of teachers".

The authors apparently rely on the freedom and the capacity of British teachers who are supposed to make up their own curriculum and use a number of sources rather than one authoritative text book.

As to sequence and timing,

> "The books can be used in any order and there is something to be said for using them over several successive years, say one book for part of a year over a period of three years ..."

and

> "From our experience it would seem that the books can be used as the basis for work with students throughout the secondary range including General Studies in the sixth (top) form.".

The project relies much on the teacher who will take or leave "People and Resources" as he feels to be competent. No special teacher training materials or courses were prepared after the basic units had been published commercially.

2.4. The justification of the choice of Water Pollution as topic

All environmental programmes would agree that priority in the choice of a topic should be given to those issues, which are considered to be the most serious and urgent. Therefore the question arises: Is water pollution such a central problem in the area, for which the curriculum units were prepared, and did the projects underline the specific contexts, in which water pollution problems could be seen and should be solved in each of the countries?

There are no clear criteria to rank environmental problems as to their seriousness, (see section 2.1.) but some relative assessment can be attempted.

Where pollution and other conservation problems are dealt with in a more or less systematic way, as in "People and Resources", no special justification has to be found for the inclusion of water pollution as one of the topics. Most programmes, especially those which work under the constraints of a school system with rigid rules for time-tabling, concentrate on special aspects of water pollution.

In "Problems of Water Pollution" the emphasis is on rivers, in "Man and the Environment" on Lake Erie, in "Man and Water" on the context of water supply generally and in "Shoreline Management" on regional planning.

In Germany, analytical tests have shown that most flowing waters are fairly to strongly polluted. They fall into categories 2 and 3 of a 4 point quality scale (RAT VON SACHVERSTÄNDIGEN, 1974). Considerable parts of major German rivers like the Rhine, the Neckar, the Main and others reached already the overpolluted category 4. Only the Alpine tributary rivers of the Danube are still left in the first category. In spite of the effort of the last 15 years, pollution was 1974 worse than ever before. Surely a good reason to choose water pollution as central topic of an ecological curriculum unit.

While in Germany water pollution is discussed usually in connection with rivers, in the United States lakes have become objects of major environmental controversies, and above all Lake Erie. After some, rather premature, obituaries had declared "Lake Erie is dead!", it seems to recover and no longer to be the most endangoured water area in the United States. This is just the reason it was chosen by "Man and the Environment" as topic and example of a controversial issue, which should be examined carefully and objectively. The exclamation mark was exchanged by a question mark: "Is Lake Erie dead?"

Hawaii's major economy branch is tourism and many of the rapidly growing residential and industrial areas are close to its shoreline. Kaneohe Bay is a classical example for the effects of the accelerated postwar development of a bay area and the resulting pollution agents on the main asset of the tropical bay: its coral reefs.

The dumping of about 3.5 million gallons a day of sewage, (from which the large particles, but neither nitrates nor phosphates are recovered), the increase of red, muddy stream water entering the bay and the concentration of dredging operations have been the main agents for the destruction of the reefs (MARAGOS, 1970).

This kind of water pollution affects Hawaii probably more than any other pollution problem and, therefore, is justified as central topic also from the point of view of environmental monitoring. But as we have seen (Section 2.2.1.), its choice was influenced also by educational factors.

Israel suffers a very serious shortage of water. Already 1970 it was estimated that more than 90% of its water potential was used (JACUBOVITS, 1971). Rainfall is not enough to supply all the needs of irrigation of a highly developed agriculture in a semi-arid climate. Agricultural settlements receive only 50-60% of the planned water allotment. Growing industries have discharged for years their water into the few, very small streams, ground water is rapidly being polluted (LASTER, 1976). No doubt, the choice of water supply and pollution as central environmental topic was justified. The same can be said from the point of view of pollution monitoring about the decision to emphasize pollution problems rather in the ground water and in streams than in Lake Kinneret. Measures taken to heal the Kinneret have been successfull in stopping a further deterioration and even in bringing about some improvements (SERVICE FOR THE PROTECTION, 1976).

2.5. How strong were various influences on the choice of topics?

In an erlier section (2.1.) four main factors were identified as having an influence on the choice of the environmental topic by a curriculum team: importance or urgency from the point of view of environmental monitoring, relation to the over-all educational planning, expertise available to the planners and appeal to students.

The last factor seems to be nearly axiomatic in education curricula, initiated and directed by educationalists and starting with student-centred objectives. All the projects reviewed stress the point, that the topic and the activities developed meet with students' interest. None could show if it was the topic as such or the activities, which caught students' interest. Content and form are too intricate to be separated.

Yet it seems that in some cases, pedagogical and methodological considerations come into the decision making process at an earlier stage than in others. In "Man and the Environment", Lake Erie was not chosen because of its objective importance in pollution monitoring, but rather in spite of it. Just its controversial character appealed to the development team much more than any clear cut major pollution problem. In "People and Resources" motivational factors seemed to have been influential in giving to water (and air) pollution more emphasis than to others. In "Problems of Water Pollution" the availability of student experiments (and experts to advice) was a strong factor in the choice of the topic.

It is usually in the larger national projects and in more highly centralized systems that subject matter experts play an important part in the choice and the development of student experiments. In both Israel and Hawaii, experts participated in early planning stages and became more and more involved during the development process. Probably two reasons contributed to this trend: Educational systems, and specially state systems are kept more accountable for their decisions than independent projects, which act more or less in a "free market" situation, in which each potential user is free to choose or reject the offered product. In state educational systems, curriculum projects tend to look stronger for the backing of the scientific community, which in the past has often attacked the educational system of lagging behind scientific, technological and other developments.

On the other hand state projects often have also easier access to subject matter expertise, be this because this is available within the system itself or because of the readiness of experts to service (and influence) the community, even when budgets are not higher than in independent projects and the expert often is paid only expenses and small fees.

Again project working within a national or state framework (like Israel and Hawaii in this study) tend to be influenced strongly by central planning - both in the educational and the subject matter spheres.Schools are expected to educate future citizens who will

take part in national decision making and then look for the experts for help in defining the most important areas, in which these decisions will have to be taken.

2.6. Summary

Four main criteria influence the choice of the central topic in environmental education programmes: the importance of the issue from the point of view of environmental monitoring; the attraction which the topic itself or the related activities have to students, as well as their ability to cope with the issue; the expertise of the planners and the influence of the experts which participate in the curriculum project; and often also the relationship between the project and general, educational planning in a given country. These criteria are common to nearly all projects, but the relative emphasis, which is given to each of them, changes from project to project.

In all the reviewed curriculum units could be shown, that water pollution was an important and urgent topic from the point of view of environmental monitoring. Also the chosen subtopics and emphases (brooks and rivers in Germany, Lake Erie in the U.S., water shortage in Israel, costline management in Hawaii) were found to be justified.

The reason for emphasizing a partial issue is often that the amount of time, in which the whole problem can be studied, is very restricted. The use of examples from the most relevant, specific topics is typical for projects, which work in a wider framework (e.g. a biology curriculum). A more systematic treatment of environmental problems is usually found in projects, which do not indicate, in which subject and when the unit should be taught.

The influence of experts on the choice of a theme and on the development of learning activities seems to be stronger in larger projects and those, which are hold accountable for their decisions (e.g. national projects). This may be so because of the backing these projects need or in order to give scientitsts

a chance to influence the planning. As could be expected, in countries with central educational planning the preparation phase is more pronounced and detailed as in independent projects.

The backing by experts can be of great importance in the implementation of a curriculum. For instance, in Israel some professors of biology were involved in the decision to include also socio-cultural aspects of water pollution into the framework of the biology curriculum. Their prestige helped the new units to be accepted into the biology curriculum without too much opposition.

Projects differ also in the emphasis on educational objectives. In Problems of Water Pollution group work is emphasized, in Sink or Swimm "the science and art of decision making". In Man and the Environment the objective investigation of controversies, which arouse emotions, is considered to be one of the main goals. Man and Water and Shoreline-Management expect their students to get involved actively in the improvement of their environment. In the latter project, as well as in Problems of Water Pollution the integrative part of social science in environmental education is emphasized.

In all projects, the possibility to conduct practical experiments and to analyze was a decisive factor in the choice of the topic. In some cases, e.g. Problems of Water Pollution, the team started with the development of the central investigations and enlarged the framework of the curriculum unit in the trial stage. In other projects the basic lines were changed only slightly after they had been fixed during the initial deliberations. This seems to happen mainly in projects, in which the policy was laid down by a committee of experts from various educational and subject matter fields. In this respect it did not make much of a difference, if the expert committee was created by a governmental department (as in Israel and Hawaii) or by a private body which cooperated with a university (as in England).

Among the reviewed project units all three degrees of intensity in integration, which were postulated by BLUM (1973), are represented. Shoreline-Management is a typical example of a co-ordinated curriculum. Problems of Water Pollution has chapters which are predominantly biological or sociological in their approach and content and therefore this project can be ranked among the combined-integrated curricula. Sink or Swim reaches the amalgamated stage - and therefore also will have to take in account major difficulties in its implementation stage.

Chapter 3

MATERIALS PRODUCED BY THE PROJECTS

3.1. The ratio between teacher and student materials

The curricula reviewed here are at different stages in their development. Only "Man in the Environment" and "People and Resources" have published commercial editions. Although the Israeli team is now developing other topics, "Man and Water" is still published in a semi-commercial trial edition and new parts are being added. "Problems of Water Pollution" and "Shoreline-Management" are still in the trial or development phases. Therefore, table 1, which summarizes the materials produced so far, will still undergo changes as the latter projects revise their materials:

TABLE 1.: MATERIALS PRODUCED SO FAR BY THE PROJECTS

PROJECT	STUDENT MATERIAL	TEACHER'S GUIDE	ADDITIONAL (CLASSROOM) MATERIALS
"Man and Water" (Israel)	Student Text, 67 pp Programmed Text, 17 pp (140 frames)	Teacher's Guide I, 85 pp Teacher's Guide II, 35 pp (Excursions along a stream) Teacher's Guide III, 28 pp (Activities and pedagogical deliberations for in-service training)	Simulation Game "Caution Pollution" Dias for teacher in-service training
"Sink of Swim?" In "People and Resources" series (U.K.)	Student text, 48 pp	Teacher's Guide to whole series (3 + 33 pp)	
Water Pollution (incl. thermal pollution by atomic power plants) in "Man and the Environment" (U.S.)	Student text, 73 pp	Teacher's Guide, 8 pp (on MATE generally), 6pp (on water pollution investigations) annotations (approx. 15 pp)	The Pollution Game, The Thermal Pollution Game.
Problems of Water Pollution (IPN, Germany)	First information, 9pp Guide-lines for 4 groups (on different topics) 62+54+60+47pp IPN guide to group work 40pp	Teacher's Information 46 pp	2 Films 16mm (colour, tone) 3 Films, 8 mm (colour) in cooperation with FWU 46 dias
"Shore-line Management" (Hawaii)			Walrus-Hawaii

"Shoreline Managemant" is sill at a stage, when often mimeographed sheets are added or replaced earlier materials, and changes are frequent. Therefore no details on the student and teacher materials of this project appear in Table 1. Walrus-Hawaii, (see sections 3.4. and 4.6.) is a Hawaian adaptation (taking Kaneohe Bay as case study) of WALRUS I, developed by Allan Feldt at the University of Michigan so that the sea grant staff there could interact with the local community.

It is probably typical for projects, which are funded for a given period, (e.g. Man and the Environment, and People and Resources), to publish their materials at a relatively early stage, while long term projects, and especially those working under government auspices, tend to prolong the trial period and to engage in more teacher in-service training (see section 2.3.). They extend their trials not only because of perfectionism backed by the necessary funding, but also because they are more subject to criticism by educational laymen and professionals and are usually also engaged in teacher training and re-training.

Another typical feature of environmental education programmes are the additional materials produced: Simulation games (see section 4.6.) and films in which often a simulated situation is portrayed, e.g. in the IPN Film "Water and the Community" or situations are shown which students cannot investigate by themselves (see section 5.2.).

The IPN-Project "Problems of Water Pollution" is also a good example for how a curriculum project makes use of the potentialities of other specialist agents in the same educational system. Most of its films were produced by a Federal unit which produces and distributes instructional films in Western Germany.

The IPN 'Guide-lines for Group Work' were originally developed by a member of the team who prepared the physics curriculum for the 9th and 10th school years. The author was also member of the water pollution team which decided to use these guide-lines in its project.

This is one of the few cases, in which a curriculum development team uses materials produced by a sister project. Although often curriculum teams in adjoining subjects, developing similar topics, work under a common organisational umbrella, the real contacts and the deliberate use of each others materials for reinforcement is rather seldom. Because of its synthesis between research (often using theoretical models) and development and because of its organisational set-up, IPN seems to have created the conditions for an inter-team use of ideas, without forcing them into a restrictive uniform format.

How much materials should one prepare for students, and how much for teachers? This is an open question in curriculum development. The answer to it depends often on the implicit view a project team has of the needs and abilities of the teachers using the materials. The teacher's task, as assumed by the project team, will be discussed in the next section. For the moment we shall look at the quantitative ratio between student and teacher materials in the projects reviewed in this study. For this purpose alone the number of pages in students' and teachers' texts were counted and included in table 1. Of course, it does not make sense to compare projects by the number of pages they published. But the relative weight given by a curriculum project to teacher and student materials can lead to interesting speculations.

For this purpose the number of pages written for students were divided by the number of pages in the teacher guides and so a student/teacher material ratio was obtained and is presented in Table 2.

Student material is usually more illustrated than teacher guides (see section 5.1.), but since this is true for all projects, the ratios can still be compared.

In "Man and the Environment" the guide for teachers on specific points in the student text is printed in the form of a commentary, in a different colour, on the margins of the student text.

Therefore the amount of annotations written for the teacher, was then turned into an estimated number of pages.

In "Problems of Water Pollution" 4 groups of students in each class are expected to work with different materials and then report to the class on their work. Therefore two ratios were computed for this unit. The first compares the texts, which each student as member of a group is expected to study, which the teacher's guide. In the second ratio the whole student material written for students is compared with the teacher's material. In this case identical texts, which appear in all 4 guide lines for group work were counted only once. The ratios are summed up in Table 2.

TABLE 2.: RATIOS BETWEEN PAGES OF STUDENT/TEACHER TEXTS

Unit	Ratio
"Man and Water" - all guides	0,6
- main guide only	1,0
"Sink or Swim" - in "People and Resources"	1,3
Water Pollution in "Man and the Environment"	2,5
"Problems of Water pollution	
- per student	2,3
- total material	5,6

This table shows that the ratio between student and teacher texts vary considerable, from 0,6 to 2,5 or even 5,6, when we base the ratio on the writing team's effort rather than on the amount each student is assumed to read.

Such differing ratios suggest that the views of the project teams on the teachers' and students' roles might have been different too.

When a teacher's guide becomes too bulky and detailed, it may deter busy teachers from reading it. As a rule of thumb a 1:1 ratio between teacher and student materials seems to be optimal. It also opens up the possibility to print in the teacher's edition the students' text and the advice given to teachers side by side.

Only the main teacher's guide of "Man and Water" and "Sink or Swim" come near to this balance between student and teachers materials. Project teams prefer sometimes to include material which is actually aimed at teachers in the student texts, because they have come to believe that teachers tend to read student materials rather carefully in order to prepare for questions. When too much teacher material is produced the chances of being read diminish.

The rather low ratio between student and teacher texts in "Man and Water" is due to more than one reason:

1. More than a third of the "general" teacher guide consists of reprints of articles taken from the scientific literature. The team apparently thought that giving teachers only references would not be enough help, and that teachers might have difficulties in finding the sources.

2. The teacher's guide contains also detailed suggestions for further investigations, which in many other cases would have been included as option in the student's text.

3. Biology teachers in Israeli secondary schools prefer work in the laboratory over field work. Many of these teachers apparently do not feel competent enough to take their classes outside. They are usually less trained in ecology than in morphology and physiology, and fear not to be able to answer the many unexpected questions, which arise on a field trip. Therefore, the project team prepared a detailed, second guide on the preparation and execution of a field trip along a polluted stream. Much similar material appears in "Problems of Water Pollution" in the student's text.

4. In the trial period the project team found that many teachers use the texts rather in the "cook-book" style. Therefore, a larger part in the teacher in-service courses was given to pedagogical deliberations, how the materials could be adapted and used under varying conditions. The exercises developed for the in-service courses were collected in a third teacher's guide.

In "Problems of Water Pollutions" all technical details and suggestions how to plan and control the learning steps are in the student's texts, and therefore the ratio between student and teacher materials is high.

"Man and the Environment" too has a high ratio, but in this case the reason is a different one. The teacher's guide in all its parts is very concise, probably because of commercial reaons. It appears as a relatively thin supplement (on green pages), which was added in the teachers' edition to the student text. In many cases, when teachers are asked to use a new method, e.g. simulation games (in which the project pioneered), very little is said in the teacher's guide about this technique, which is new to most biology teachers. It is doubtful if the good advice "to play the game with colleagues or some of your students before hand" (p. 288) is really helpful enough.

3.2. The teacher's role in choosing and adaptating activities

All projects expect teachers to adapt the programme to the needs and abilities of their students, to the preferences and idiosyncrasies of the teachers themselves and to the constraints under which they work. But the projects differ in the amount and type of advice they offer teachers in this task.

"People and Resources" leave the adaptation nearly completely to the teachers, who are used to being responsible for their own curriculum planing. The role of the teacher is:

> "being that of an organizer and guide, ensuring the smooth running of the investigations, pointing to follow-up work and links with other subjects, acting as chairman for discussions, summarizing the results of a piece of work, sorting out the difficulties of individual students and so on"
>
> (Teacher's guide, p. 9)

Although students are expected to use the texts directly,

> "at times the teacher will need to pass on or interpret information, particulary when the previous experience or ability of students reveals inadequacies in the text".

No further advice is given on the difficulty levels of various chapters in "Sink or Swim" or how to group the students. As in most other projects, teachers are encouraged :

> "to continue their own development. We hope that the users will see the sort of thing we have done, say "yes, we can develop this further", and take off in their own direction".

Also "Problems of Water Pollution" does not define the role of the teacher in selecting and adaptating different parts of the unit. Since the schedules of the first two (of three) phases of instruction are quite fixed, it does not seem that the teacher is expected to change much before he comes to the third part,project work,which is not pre-planned. The concise "Teacher Information" do not include any suggestions how the teacher might choose between different activities and how he could adapt them to different ability levels. Students are expected to make their own decisions and are adviced in the student materials, how to proceed.

The choice between the topics is apparently left as much as possible to the students themselves. For this purpose they receive a booklet called "Preliminary Information for Choosing a Group" with the same overviews on the four topics, which appear also in the "Teacher's Information". But the final composition of the group is left to the teacher (Teacher's Information, p. 32).

"Man and the Environment" gives some advice on scheduling, especially for the case students already have investigation skills (which are dealt in the first of the programme's four units) and teachers want to emphasize environmental problems.

"Man and the Environment" assumes that some selection might be necessary, becaue experience showed -

> "that it is unwise to plan on completing all the activities in one school year",

but nothing is said about how the teacher might choose between the investigations. It is doubtful if the concise teacher's guide fullfills the promise that -

> "careful reading of the guide materials before you begin an investigation and review of the annotations during the investigation will go a long way towards assuring student mastery of the objectives".
>
> (Teacher's edition, p. T 3)

"In Shoreline Management", Teaching Notes written after trying out the materials in schools, suggest that some exercises -

> "can be teacher directed or conducted within small groups. The advantage of the teacher-directed mode would be speed and focus. The advantage of the small group approach would be greater involvement of each student in the speculating activity".
>
> (Supplement Teaching Notes, 5th Oct., 1976,p 7)

The Notes then go on to suggest two sequences of steps a teacher might take, each suitable to one of the alternative teaching modes.

"Man and Water" foresees a similar approach, with an emphasis on small group work, especially for laboratory work. In this project, as in the Hawaiian, but unlike the German project, groups of students work on a topic common to all.

In "Man and Water" some consideration is given to the teacher's task of adapting the materials to different levels of student abilities.

The Teacher's Guide 1 reports:

> "From talks with teachers who have taught the topic (Man and Water) it becomes clear that it can be adapted to different levels. For more advanced students (level A in schools, in which students are streamed) quantitative experiments and more background reading from the bibliography at the end of the students' text could be added ...
>
> For weaker students (level C or vocational classes) one can emphasize the relevance to daily life and daily problems in the use of water.
>
> Depending on the level of the class and its learning atmosphere it is certainly advisable to encourage students to bring information, which they have collected, before the whole class ..."

Out of the 15 exercises in Teacher's Guide 3, written for teachers in-service training, none was planned to train teachers how to adapt activities to different levels of difficulty or how to organize the groups. But two exercises are concerned with language difficulties. Both were influenced and actually triggered by the British Science Teacher Education Project. One exercise is a text in which all terms, which are new for students, are replaced by non-sensical words, in order to exemplify to the teacher the feeling of frustration students get when reading such a passage. The other exercise is a transcript of a dialogue between a teacher and a socio-culturally deprieved student. By the way, both exercises use courageously the project's own student texts to show teachers a possible weakness of these materials when they are not used in accordance with students' abilities.

A grading of reading materials according to difficulty levels can be found in "Shoreline Management" of the Hawaiian Marine Social Studies Project. Students are presented with 8 readings, in which experts express their findings on the pollution in Kaneohe Bay. 6 articles (mainly written by scientists, but in the daily press) are marked, in the teacher's guide, as suitable for average students and two such readings can be assigned to the same student. One article is rated as complicated and another, an extract from an original scientific report, as difficult.

3.3. Composition of Teacher's Guides

Some features appear in all five projects reviewed, although with varying emphasis. Others are specific to one or more of the teacher's guides.
The common features are:

A) Rationale and goals of the whole programme and, sometimes, of specific chapters and investigations. "Man and the Environment" keeps to a strict behavioural format. Next to each of its objectives a suggestion is given on how to evaluate if the students have attained the objective. In other programmes the Bloom-Mager influence is less obvious. "People and Resources" start with a list of key principles, abilities and attitudes. "Man and Water" formulated only over-all objectives and did not pay much attention to a behaviouristic format. The least concerned about formal objectives is "Problems of Water Pollution". Two main goals are defined, but the emphasis is on their implications for planning.

The least concerned about formal, behavioural objectives is "Problems of Water Pollution". Two main goals are defined in the Teacher's Information (p. 9-10), but the emphasis is on their implication for planning. This is done because in the IPN unit the information on water pollution is considered to be of secondary importance. The main goal is to create the preconditions which enable students to investigate the concrete problems of water pollution in their own community. At the same time objectives of social learning are stressed. Students should have an opportunity to learn and work together instead of competing with each other. Since students find it difficult to work independently when given only general instructions, the project team decided to describe the instructional process in details, but without taking from the students the opportunity to make their own decisions. Therefore the guidelines were developed.

The following criteria for the development of materials were laid down by the "Problems of Water Pollution" team:

1. Materials should be usable concurrently in two school subjects.

2. Students should be trained systematically to work for several weeks in small groups.

3. Students should get to know the problems of water pollution by investigating them outside school, in the community.

4. The materials should contain the written guidance which is necessary for students to gain meaningful learning experiences, but not the full information on all problems of water pollution.

In respect to goals and planning, "Man and Water" introduces an interesting format. A list of 11 objectives is given, of which 5 are specific to the programme and 6 are wide science education goals. Teachers are asked to decide if each of these objectives should be stressed, taken in account or discarded. The decision can be written into a column of boxes printed next to the list.

Another unusual feature of "Man and Water" is the beginning of the rationale. It opens with a critical letter, written by a student about the way he learned the topic, and how it could be improved.

B) Programme overviews and scheduling

Depending on the context of the water pollution unit, whether it is part of a wider programme or independent, the overviews and advices for scheduling vary. Wider programmes like "Man and Water" and "Sink or Swim" suggest how to sequence the unit in respect to others prepared by the team. In "Man and the Environment" water pollution has its fixed place in the course and teachers are given a tentative time schedule.

Probably the most highly structured of the units, and the one in which the structure is demonstrated explicitly, is "Problems of Water Pollution". The teacher's guide gives a time

schedule for those parts of the instruction which were pre-planned, and a detailed overview on the four main topics investigated by different student groups. For each topic objectives are given, not necessarily in strictly behavioural terms. Then the central questions and problems of the topic are spelled out, the methods are summarized and possible difficulties are envisaged. This overview is given also to students to enable them to choose one of four topics for further work.

D) Lists of materials, where to acquire or how to prepare them.

E) Methodological suggestions

Expectedly, these take up most of the teacher's guides. Since they are closely related to the character of the student activities, more about them will be said in chapter 4. The reviewed projects differ considerably in the placing of technical and even pedagogical-methodological suggestions. Some prefer for this purpose the teacher's guide, others the student's text (see section 3.1.).

F. Evaluation

All teacher's guides mention the problem of evaluation. In some it is emphasized, in other treated only very marginally. "Man and the Environment" encourages the teacher to look for positive changes in behaviour (p T5). After learning -

> "(students') interest and enthusiasm should be consistently higher. They should ask significant questions much more frequently. Experience has shown that there is also likely to be a reduction in the number of disruptive acts in the classroom. These are obviously signs of success, and just as important as the written evaluation devices".

These devices are mastery items, for self-testing by students, and "checkpoints", which usually describe a situation that is related to a student investigation, but new for the students. These checkpoints are available from the publishers, separately from the teacher's guide.

In "Problems of Water Pollution" an annex is called "aspects for achievement evaluation". The project team makes it very clear that it opposes individual achievement evaluation in a unit which is built on group work because such an individual evaluation enhances competition instead of cooperation. But since teachers are expected to grade their students, the following model is proposed: Students pass the Basic Test, which contains mainly simple items to assess comprehension. Students can improve the "pass" grade received in the Basic Test by trying the Complementary Test. In this test omissions or wrong answers cannot lower the grade achieved in the Basic Test, but good answers add points.

In the Teacher's Information (p. 23) the thinking behind this procedure is explained:

> "This evaluation model rewards cooperation between the groups, because in both tests, but especially in the Basic Test, tasks are posed from all four thematic areas. Therefore, those students, who work not only on their own group theme, earn points".
> Students have a chance to cooperate also in other thematic areas during planning stages of their group, but also by informal cooperation between work groups with intersecting thematic areas and, finally, when the groups report to the class plenum.

The authors of "Teacher's Information" deplore that this model does not prevent competition within the group, and therefore students might withhold knowledge from their group partners, in order to outplace them in the test. Therefore teachers are advised to point out that a full exchange of knowledge leads to a higher achievement level of the whole group and so also to higher chances for the individual student to get a high grade. Even the possibilities of a "grade pool" for all members of a group is discussed.

"People and Resources" offer only little advice how teachers could evaluate its success with students in a school situation. The teacher's guide expects that -

"some knowledge should be learnt, some facility of analysing data will be acquired, and, of course, tests could be devised to measure success in these".

"However, we would place far more importance on the effect on the behaviour of students".

Then some examples for signs, are given, which show that the educational work done was justified. These are:

- Student view a TV programme on an environmental issue, on their own initiative, and later talk about it in a committed way;
- In their discussions the students look at several faces of the issue, calling on ideas from a range of subjects;
- In their discussion, they examine whether evidence is offered critically, carefully and without complacency;
- They may join in local conservation activities and they may merely switch off an unnecessary electric light more often.

"Man and Water" reports in its Teacher's Guide 1 (p. 4) a comprehension text given to trial students, but the results were not summarized at the time the Teacher's Guide was published - as so often happens when a curriculum team prepares a formal achievement test for formative evaluation, but revises its material on the basis of the much quicker, informal feedback. No advice is given to teachers how to evaluate their own students. They are only given the university address of the team member, who was the project's subject matter specialist.

G) References to further reading on environment issues for both students and teachers are part and parcel of most programmes. But surprisingly, they were not included in "Problems of Water Pollution", although it can hardly be assumed, that all teachers in the project's target population have a full knowledge of this relatively new topic and its interdisciplinary implications.

"People and Resources" give a general introductory reading list on broader environmental issues and then, for water pollution, a list of references, which are mentioned in the Guide and a list for further reading.

"Man and the Environment", on purpose, refrains from giving - "long bibliographies of books and articles that most teachers cannot acquire or wade through. Instead, following the Background for each investigation are Basic References and selected Additional References".

The background notes are very concise. "Man and Water" apparently also assumes that teachers have difficulties to find the suggested articles and therefore those who seem most relevant to the team are reprinted in the Teacher's Guide itself (see secion 3.1.).

All teacher's guides offer also advice on suitable films and other audio-visual aids.

H) Teacher Planning

All projects assume explicitly that teachers will plan their own classroom schedules, but only some of the teacher's guides advise them how to do so. "Problems of Water Pollution" gives a detailed overview on the different phases of the instructional unit, what to do in groups and what in the class plenum. "Man and Water" prepared a table of topics and leaves enough space for the teacher to write down the amount of time he wants to spend on each, according to the emphesis he gave to the different objectives. The other projects either leave the planning fully to the teacher or assume that he follows the text.

I) Suggestions for further projects and follow up

Both "Man and Water" and "Problems of Water Pollution" also offer teachers a list of ideas for additional investigations and follow-up projects.

J) Group Work

All projects seem to assume that some work will be done in groups, but few include in their teacher guides advice to teachers on the tasks, the functioning and the managing of the groups.

"People and Resources", "Man and the Environment" and "Man and Water" have no special sections on group work in their teacher guides. None of the methodological-pedagogical exercises in Teacher's Guide 3 of "Man and Water" is on group work.

"Shoreline Management" points out that small group work tends to lead to a greater involvement of each student in speculating activities, but that more time is needed and group work might be diffuse. The Teaching Notes do not suggest how the groups might be constituted.

The strongest emphasis on group work can be found in "Problems of Water Pollution". In this IPN unit two objectives are elaborated in the Teacher's Information (p.9):

"1) Students should learn to investigate and evaluate the complex problems of water pollution in their own community, in an interdisciplinary and multiperspective mode;

2) Students should become qualified to continue their studies with an own project."

For both objectives the experience of working efficiently in groups is necessary. To achieve the first objective two

things are important: Students should learn to divide their tasks according to a sensible division of labour. They should not be carried away by the special knowledge and skills gained, loosing sight of the problem as a whole. Therefore the four different topics, on which the groups work, were planned to articulate with each other to give a cohesive whole. From time to time the groups stop their work, exchange information and plan together the next phase.

In order to plan and execute a project efficiently, students need some basic qualifications (Ibid, p.10):

- "team ability, the ability for a successful and enjoyable cooperation;
- learning independence, the ability to look for information, and digest it independently and doing justice to the problem;
- recognition of a problem and awareness of being involved."

The Teacher's Information then goes on to explain how groups should be organized. Each student reads the 'Preliminary Information on Choosing a Group', which contains details on the objectives, the problem areas, the methods and possible difficulties of the four group topics. Then he writes on a piece of paper his first and second choice and hands it in to the teacher, who will form groups of 3-5 students. By doing so the teacher will take into consideration the students' preferences, but he will make sure that each topic is investigated by at least one group.

The Teacher's Information goes on to describe some cases in which the teacher might ignore student's wishes. There are (p.32):

"- Extreme heterogeneity of achievements. (Aim of the correction: Each student should have a fair chance to contribute to the content discussed in his group);

- Open disturbancies in the personal relations. (Hostilities, antipathies which are difficult to overcome. Aim of correction: No unnecessary aggravation of the cooperation);

- Cliques with "Anti-school culture".(Aim of correction: To dispel the cliques and to integrate their members into the class formation and into its topical work)".

K) Field Work

Last but not least among the features of the teachers' guides: It could be expected that environmental programmes, and especially curriculum units on water pollution, emphasize the need to investigate these issue on the spot, and therefore advise teachers how to plan and execute field trips.

"Sink or Swim" contains a relatively short field investigation in which indicator organisms are used to assess water pollution. The Teacher's Guide relates only briefly to problems a teacher might encounter on his field trip: A references to a more detailed identification key is given and its limitations are pointed out. Teachers are reminded to check areas to be surveyed for suitability, e.g. safety of the bank, or, if it is privately owned, to get permission to use the ground. Shallow riffle zones are recommended for sampling. Care should be taken that the samples taken represent all the micro-habitats present. It is then suggested to make a survey along the river, taking care the investigated spots are comparable.

In "Problems of Water Pollution" tests on the oxygen content and on indicator organisms in streams are the central activities for two out of the four parallel student topics. All technical details are given in the student's text in order to train them towards independent work. The teacher's guide contains no further advice on the field trips, which are done by the students themselves.

The question "What water is suitable for the investigation" is posed in the student's text and is answered summarily by "each running water, which is not dangerous". Students are warned that deep streams with steep banks are dangerous and that sewers contain often disease germs.

The most intensive treatment of problems arising in a field trip can be found in "Man and Water". This project team prepared a special teacher's suide for excursions along a stream. It contains the following features:

1) Suggestions for single excursions or full projects, which can introduce students into ecological surveying. Teachers are advised to ask for assistance given readily by instructors of the Society for the Proctection of Nature, and to participate in special training schemes.
2) Suggestions how to choose a suitable stream. One should look for the following stations:
   a) A first station from which the landscape dominated by the river is impressive.
   b) A second station, at which algae have developped due to pollution by phosphates and nitrates from fertilized fields.
   c) A third station, at which also the effect of industrial and residential sewage can be observed and the stream is "dying".

   Here the emphasis is on the river's "life history", the study of which should complement the technical measurement taken by students.
3) Preparing the class for the excursion. Different groups of students, helped by the teacher, review the geography of the area and repare detailed maps and the various chemical and bacteriological tests which could be made.
4) List of Materials which should be taken along and a list of suggested activities.
5) How to organize students for parallel investigations. Here, as under point 4), many technical details are given, which also appear in "Problems of Water Pollution", in similar length, but there in the student's texts. More than in the other units reviewed, the differences between micro-habitats are stressed. The emphasis is rather on getting to know the flora and fauna in its natural habitat than to measure indicator organisms quantitatively. Quantiative work is done in connection which chemical and bacteriological water tests and in productivity assessments.

6) Transfer of organisms from the stream to the classroom aquarium. Teachers are warned to return protected species into the stream and to take from the other organisms only few specimens. Instructions are given how to transfer the animals to the classroom and how to keep them there for further investigations, especially when they were taken out of streams with high salinity.

7) Suggestion for summing up the excursion. These include examples for tables, suggestions how to prepare graphs which could serve as nucleus in an exhibition and stageing a mock trial to probe "if the conservation authorities did enough and how the situation could be improved".

Teacher's Guide 2, "Excursion Along a Stream" ends with references and a concise definer for sweet water fish and snails.

3.4. Composition of student texts

In this section we shall look at the topics dealt with in the students materials, and in the next section how the texts are organised.

All the five curricula reviewed contain biological and social-science ingredients, but they differ distinctively in their blend. "Man and Water" and "Sink or Swim" have a conservationist outlook and especially the first is soaked strongly in ecology. On the other side of the spectrum, "Shoreline Management" represents a typical social studies approach. The other projects come in between these in regards to content and activities.

The student text of "Man and Water" starts systematically with a review of environmental factors and examples of water pollution from the Bible (in 2.Kings, 2, 19-22) and Jewish traditional literature. Then the text emphasizes that all organisms contain water and that water is consumed in varying amounts also in industrial processes and at home.

Using their families' water bill, students computate their average daily water comsumption, compare it with the national average and try to explain differences between these two. This comparison leads to reading chapters on Israel's restricted water resources and their use, and on the ways in which these resources are being polluted.

In the second chapter, water tests are introduced: turbidity, colour, smell, acidity (pH. as "black box"), dissolved oxygen (simplified titration). Students are told how they can find out how plants and/or animals in an aquarium affect pH. Then the role which detergents play in pollution is introduced and this leads to a phosphate test.

Other pollutants discussed are mineral oils and bacteria. Again the approach is systematic. First bacteria are described and then classical case studies of bacterial diseases are presented in brief. This is followed by bacteriological water tests - counts of all bacteria and of coliforms, using different substrata.

The chapter on the treatment of drinking water begins historically with the presentation of archeological pictures. Then modern filtration and chlorination is sketched in a few lines, without pictures or drawings.

In a summarizing experiment, the effects of the main pollutant groups on plants and fish in aquaria are investigated. These pollutants are: treated and untreated home sewage, agricultural drain (simulated by passing a fertilizer solution through a pot with soil), detergents, industrial waste (simulated by copper sulphate) and mineral oil. Students apply the tests they have learned so far, as well as an algae concentration test.

The student text ends with three exercices, adapted from "mastery items" in "Man and the Environment".

"Sink or Swim" covers similar content areas, but the approach is less systematic. Although emphasizing historical case studies throughout the unit, it does not begin with them or with "Water as environmental factor", but prefers to start directly with water in the student's home. In this programme too, students try to assess the amount of water they use at home, but with another method: students measure the capacity of the bath, cooking and drinking vessels, washing, etc... and multiply by the times each is used daily. In this way more emphasis is put on measurement, but because of an accumulation of errors

the final result will probably be less accurate than in the water-bill method. (Since in Britain households do not pay their water rates per unit used and have no flow meters, the water-bill method could not be used).

The first water test in "Sink or Swim" is on bacteria. No coliform counts are suggested in the students text and the programme seems to assume that students know already what bacteria are. Testing for coliforms and the water pollution tests, which are fully explained in the student text of "Man and Water" appear in "Sink or Swim" in the Teacher's Guide.

Only now, after the students have been involved in practical work, the terms "environment" and "pollutant" are explained. To show the effect of pollution by organic matter, a hay infusion experiment is set up. It demonstrates also the correlations between organic matter, bacterial growth and dissolved oxygen (yet the latter relationship is not made very clear in the student text).

The Thames around London serves as case study. A 19th century report on the state of the river, discussed in parliament, and contemporary cartoons introduce the historical aspect. Then a graph and a map is used to give data on oxygen measurement along the Thames, during the 1930's, 1954 and 1969. Students are asked to draw conclusions and to generalize. Then ,indicator animals (but not algae) are introduced and a river survey is planned. This survey is less elaborate than the excursion along a stream discussed in Teacher's Guide 3 of "Man and Water".

Also the next chapter, on water pollution and disease, has a parallel, contentwise, in "Man and Water", again the approach is different. In both curricula the cholera epidemic in London, 1854, is mentioned. "Sink or Swim" uses it as a case study and exercise in the analysis of data. In "Man and Water" it is quoted as one of the steps in discovering the connections between cholera, water supply and water treatment, with the Hamburg cholera epidemic of 1892 as final case in

which it was shown that the germs are not transmitted in treated water.

In the chapter "future needs" in "Sink or Swim",drawings inform how much water ist needed to produce various industrial articles, how much the water consumption will grow in future, that the rain falls mainly in less populated areas, in Britain, and how the water cycle is used by Man. Then water cleaning by filtration, chlorination and sewage treatment is sketched. As in "Man and Water" this part is kept short.

Then an interesting section on conservation of water follows. The central question in this section is how water could be saved in a potato crisp factory. The unusual features of this exercise will be discussed further in section 4.7, when we shall look at problem solving and system analysis.

Also a Swedish technique how water in the home lavatory could be saved (a feature not mentioned in other programmes) and desalinated seawater as a new resource of water, are discussed.On the last page students are invited to draw up a policy for controlling water pollution in a particular areas. Such a suggestion does not appear in "Man and Water" where the national policy is explained and students are only called upon to help in saving water and in the prevention of pollution.

"Sink or Swim" was apparently written with an urban population in mind. Groundwater pollution by agriculture sources is not mentioned. In the schematic drawing on man's use of the water cycles there is an arrow from the river to the farm, indicating irrigation, but no reversed arrow. Other features, which are not dealt with in the student text of "Sink or Swim" are detergents and mineral oils as pollutants. (The first, but not the second, is mentioned in the teacher's guide).

The IPN Unit "Problems of Water Pollution" has two distinctive components, a biological and a sociological. The first contains many of the content areas which are also common to "Man and Water" and "Sink or Swim". Much emphasis, in this part, is put

on actual student investigations of a polluted stream.

The degree of pollution is estimated in three different ways: through the measurement of dissolved oxygen and of the biochemical oxygen demand, using the iodometric method, through the identification of indicator organisms and through an assessment of the change in colour produced by iron sulphide, which becomes conspicious where organic matter accumulates in the absence of oxygen.

The iodometric method is used as a "black box", similar to "Man and Water", but with more sophisticated equipment and less use of chemical terms. "Sink or Swim" does not recommend quantitative methods of measuring oxygen concentration, arguing that accurate chemical methods are too complex. The identification of indicator organisms takes a more central place than in "Sink or Swim" or "Man and Water". An 8mm film, a series of dias and detailed descriptions of the organisms were prepared, as well as another 8mm film on how to collect the organisms. The third method of stream pollution assessment, by the colour of iron sulphide, is not used in the other programmes.

The group of students, who measure the dissolved oxygen in water, goes on to the study of regeneration of the polluted streams, and to the biochemical oxygen demand - two concepts not dealt with in the other student texts. (The latter term is briefly mentioned in "Man and the Environment", but there the concept is not explained and no experiments or computations are made).

In "Probleme of Water Pollution" the dying of fish, especially in summer, is correlated with changes in the oxygen concentration, when the temperature rises. Temperature as factor in water pollution is not discussed in "Sink or Swim", or in "Man and Water". It is introduced by "Man and the Environment" in the context of industrial hot water sewage, a theme not covered by the other programmes.

In spite of the emphasis on the social aspects of water pollution, the role of polluted water in the spread of diseases, the water supply and conservation problems are all not discussed in "Problems of Water Pollution". The connection between transmitters of diseases and sewage is mentioned only incidentally. Historical aspects are missing all together. Probably because of the preoccupation with oxygen and organic matter, nitrates and phosphates and their role are not discussed. The latter is dealt with in one sentence only, in connection with detergents.

The second part of "Problems in Water Pollution" is dedicated to the social aspects of water pollution and especially to the question: What does the community do for the cleanliness of the water and how do different people look at the problem?

Students learn to speculate, to analyze texts and to survey the different economic interests and attitudes of people, who play a role in the community. In this context they learn also about ordinances. They are encouraged to propose solutions for water pollution problems in their community, but the programme does not suggest that they could set a personal example and start by saving water and reduce pollution in their own home. This is surprising, because in other respects this programme is very student centred.

"Man and the Environment" has a more restricted water pollution content, when compared to "Man and Water" and "Sink or Swim". Similar to "Sink or Swim" it starts with a dramatic photograph, which highlights one of students' relationships with water - a danger sign saying "Water polluted - no swimming". Then household products ar mentioned as pollutants, but no survey of home water use is suggested. The problem of restricted water supply is not dealt with.

Students are encouraged to plan and execute experiments on the possible effects of a houshold product on a plant or animal living in water. They are warned to stop the experiment at once if it looks like the chemical is seriously harming the organism.

The second "Investigation" (chapter) is a case study of Lake Erie. Students are presented with a data bank in form of tables, maps and diagrams related to Lake Erie and they are asked: "What is wrong with Lake Erie?" The data are on:

- change in organisms over a 30 years period. These include small animals which require a high or low oxygen content as well as commercial fish and algae;
- coliform concentrations;
- chemical oxygen demand;
- the amount of waste water flowing into various parts of the lake.

Also geographical items like the lake's drainage basin, its bottom shape and patterns of water flow are mapped and a table summarizes an experiment (from the literature) which shows the increase of nitrogen, phosphorus and algae growth after adding sewage to lake water. A list of commercial detergents (and their manufacturers) and the percentage of phosphate in each product is added.

Students are asked first to analyze the data for patterns and then to develop a plan, how Lake Erie can be helped. In "Mastery Items" (see also section 3.5.) students are also expected to use data to decide which of two lakes is more polluted, to decide what questions are relevant to another lake pollution investigation and to decide which of three suggested plans is the best to save a fictitious lake.

The whole Lake Erie investigation is analytical and theoretical. No parallel experiment or field trips are hinted at in the text. The same is done for the third water pollution investigation in "Man and the Environment":"What is the price of progress?" In this chapter thermal pollution is looked at in a historical view.This time the data are on a fictitious city and cover four twenty-year periods and are in form of a board game. Students find out, that different industries contributed more than others to a rise of the temperature in the city's river.

When students come to the present time, they are asked to decide if an atomic power station should be built near the town. This problem is approached via a simulated debate before the State Health Board. The roles of the board officials and the representation of groups with vested interests are described. A data bank describes the physical and biological characteristics of "Serena Lake" and its present use (which includes already a power station using coal). Then the operation, the economics and ways to remove heat from power plants are explained as well as the effect of adding heat on algae, fish oxygen and on whole food webs.

Summarizing it can be said that "Man and the Environment" prefers a social interaction approach to two partical case studies, practically without laboratory work, over an experimental and more extensive treatment of the subject, during which students gather themselves at least some of the data. Biological and sociological contents and methode are fully integrated in "Man and the Envrionment".

"Shoreline Management" is by definition and planning a social science unit and, therefore, no biological or physical experiments would be expected. (These will be developed in a marine science unit feeding into "Shoreline Management"). But for a social studies unit the science content, on which it bases the planning of the future, is astonishing. Students deal with a lot of scientific data and issues.

Students are introduced into "Shoreline Management" by playing the Walrus simulation game which allows students in the programme to experience the problems facing Hawaii's bay areas, among which pollution is a major one. Players are expected to draw from their game experience as they move into more concrete problems and theoretical concepts during the remainder of the course.

In the Hawaiian version of Walrus (1) participants are grouped into five groups representing different economic interests:

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(1) On the adaptation of the game - see section 3.1.

two teams with agricultural interests and three urban teams. The urban teams are further characterised by specialisation in either industrial, retail or recreational activities, so simulating the island's major economic groupings. These teams and a government interact throughout the game to develop the region and grapple with the problems of urbanization and pollution. The teams buy, sell or lease land, and develop it; they elect representatives to the local governing body; pay taxes; and try to balance the alternative and often confliction goals of financial profit, community planning and environmental conservation. By playing the game, students come to realize the necessity of planning in order to avoid environmental degradation of Walrus - a simulation of Kaneche Bay on Oahu, the Hawaiian island with most of the State's population.

Water pollution plays an important part in this game. No construction is permitted without adequate water or sewer service in the vicinity. The extension of service lines must be paid for by the users and the prices go up realistically, if a booster station is needed to overcome elevation differences.

The quantity and quality of both water and sewage are measured by an index called K. It is computed at the end of each round and shows pollution inputs of the present and previous rounds. Pollution levels are determined by the game directors (the teacher) by using two ratios, which are realistically based on the bay's cleansing action and its currents.

The K pollution or also describes the capacity of water and sewage plants, the amount of water required and the amount of sewage generated by a particular land use. The rules are:

1. "Water from a river or stream may be used directly by agricultural units without appreciable treatment cost as long as the pollution levels is 5 K or below. Water with higher pollution levels must be treated before it is used.

2. The efficiency of a sewage plant is normally 80%. Efficiency may be raised an additional 10% by increasing the operating cost of the plant by 25%. Efficiency of the septic bed is 50%.

3. The capacity of a water or sewer plant may be increased up to four times by the payment of an additional 10% of the initial construction cost for each 5% increase in capacity.

4. Quality of life cost. The bay has a maximum allowable total pollution level of 60 K. At 60 K and for each addition of 10 K over the allowable limit, all residential agricultural and retail units will be assessed $ 100 of their income for each round. The residential units can petition the court to transfer this cost to the major sources of pollution..."

(Participants'Manual, p.22-23).

Here the debate, if the polluter or the victim of pollution should pay is highlighted.

Of course recreational industries too are strongly affected by rising pollution levels. Their income can be reduced by 100%, when pollution rises above 30 K in their vicinity.

To be realistic, a water pollution map of Walrus (in reality Kaneohle Bay) is provided to indicate and help control the pollution in both the bay and the streams. The map shows which residential units are serviced by the sewage treatment plant. The discharge of a stream into the bay is the accumulation of all individual discharges into that stream. The total discharge from the sewage treatment plants and the discharge from the land bordering the bay is calculated using two ratios. The first ratio is for calculating the pollution in the relatively stagnant waters of the inner bay, taking into consideration the cleansing action taking place there. The second ratio reflects the more effective circulation patterns in the middle of the bay brought about by currents. The Water Pollution Map gives the boundaries of these two sectors.

The Participants'Manual then goes on to demonstrate how the pollution index K is calculated every round and how it can be charted efficiently.

Every round the water pollution situation is discussed, based on a report presented by the Mayor or the civil servants of Walrus.

The content of this game was discussed in some detail because it is exceptional among the curricular units on water pollution reviewed here. Although most others also include simulated exercises or board games, none developed such an elaborated and realistic model of an actual area threatened by pollution. The differences between the simulations and games used will be further discussed in section 4.6.

After Playing the Walrus game, high school students of "Shoreline Management" look at the physical setting of the Kaneohe Bay area. This enables them to define and visualize the geographic parameters of the area they will continue to study.

Then the major question "Why Shoreline Management?" is asked. Students read a short history of Kaneohe Bay which refers, i.e., also to stream diversions and their effects on coral reefs. Students speculate about the changes and possible cause - effect relations. In this case sewage and soil erosion are both effects (of man's activities) and cause (of coral destruction).

Alternative sewage disposal methods and a plea for replanting cleared land as anti-erosion measure are introduced. Students learn also about relevant laws and ordinances, and how in a concrete case public opinion, channelled through the appropriate proceedings, has succeeded to stop development plans, which might have contributed to further deterioration of the environment.

3.5. The format of the student texts and self-evaluation

Most envrionmental curricula, and indeed instructional programmes generally, organize student activities in a temporal sequence which represents the logical development of the content and the central ideas, and they write the student text accordingly.

An exception is the IPN unit "Problems of Water Pollution". Its Group Guidlines are divided into three parts, made especially conspiciuous by being printed on differentially coloured paper.

In the first part - "Guiding Steps" (green) - suggestions for work procedures are made. The authors intend to help the groups to fulfill their tasks, without taking from them the decisions. Students are expected to read the Guiding Steps and then to discuss them and use them in their planning of the group's work.

The second part (white) contains reading texts, which give factual background information. In other curricula units such texts would usually be dispersed between the activities or be printed in separate booklets, if the objective is to educate students towards the use of a library and of professional and technical literature.

The third part of the Group Guide ist called "Control Steps" (orange) and is an interesting approach towards self-evaluation. The typical question asked in this part is "Did you think about X of Y?". The Control Steps give students a chance to review their own work critically, both contentwise and in respect to the efficient functioning of the group. Although in the IPN unit no distinctive roles are given to group members as, for instance, in "Inquiry Role Approach" (LOCKARD, 1972, p.635). Students are reminded to check, if the group functions effectively.

The separation of such "Control Steps" seems to be justified because the project wants students first to try their own way and only then go to the "Control Steps".

Some facets of formal chapter structuring are abvious also in "Man and the Environment". Each of the four major units is divided into 5 - 8 "investigations". Each investigation consists of a number of problems, usually introduced by a question, and some "Mastery Items" for students' self-evaluation. These items emphasize problem solving rather than knowledge. Immediatily after the Mastery Items a key, printed

upside-down, gives the best answer or clues for the solution prefered by the authors.

In "Man and Water" students can evaluate themselves by using a programmed text. They are told that -

> "the programme should help you to learn concepts and ideas which appear in 'Man and Water'."

In some frames, a number refers to the page in the students text, on which the concept is explained and students are encouraged to go back to their text for further clarification.

3.6. Summary

Projects, which are funded only for a restricted period are usually forced to produce quickly and to concentrate on the most important items - student text and teacher guide. They are only seldom in the position to develop additional materials or to engange in teacher in-service training, although without these the ideas of the project become quickly watered down.

The quantitative ratio between student and teacher materials is different from one project to the others. It corresponds mainly to the role, which teachers and students assume in the project.

It seems that also different assumptions about when a teacher is mostlikely to read the advice given, if it is printed in the teacher's guide or in the student text, were decisive in the development of those parts in the curriculum which are written for teachers. Teacher guides are sometimes very elaborate and include extensive excerpts for articles, if the project assumes that teachers might have difficulties to get to the sources. Where independent student work is emphasized, as in Problems of Water Pollution, the ratio between student und teacher materials is especially high. But where the teacher and his problems is the main concern of the project, as in Man and Water, the amount of teacher materials is conspicuous. In such a case part of it might be written with teacher in-service training in mind.

Sometimes due to commercial considerations the teacher guide is so concentrated that it can be printed as addition to the student text in the same volume. This was done in Man and the Environment.

The role which teachers play in the choice and in the adaptation of the activities is different from project to project. It is most conspicuous in England. On the other side, in Problems of Water Pollution students can choose their preferred topics to a wide extend.

The elements common to all teacher guides are: Rationale and objectives, summary of the characteristics of teacher- and student texts, preview over the content; lists of the materials which will be used and methodological suggestions how to plan the lessons. Usually also evaluation is discussed, but projects differ very much in their approach to this issue.

It seems that objectives are not longer expressed so much in behavioural terms as they used to be some years ago. Only Man and the Environment is very careful in its formulation of objectives. Man and Water tries to involve the teacher in the choice of objectives and in the emphasis which should be given to each of them.

Problems of Water Pollution is more than others concerned with grading and especially with the education towards cooperation in a school system, which fosters competition and the halc of high grades.

Some projects offer extensive bibliographies, others believe that this is of no value, if the teacher cannot obtain readily the sources (articles in professional journals). Therefore Man and Water, for instance, included in the teacher guide many reprints of articles. This project also published a special teacher guide, how to plan and conduct excursions. Man und Water and Problems of Water Pollution describe the teacher's planning steps very extensively. They give also

considerable thought to follow-up projects.

All projects assume that students work in groups, but the organisation of the groups is dealt with extensively only in Problems of Water Pollution and to some extent in Shoreline-Management.

The content of the student texts varies from distinctively ecological (Man and Water) to predominantly social (Shoreline-Management). Man and Water and Sink or Swim cover many topics of the water pollution issue. The other projects concentrate more on specific aspects. While Man and Water ist constructed rather systematically, Sink or Swim starts with the environment of the students and then goes from the practical to the theoretical. In this project, as in Man and the Envrionment and Shoreline-Management, historical elements are emphasized. These appear also in the other projects with the exeption of Problems of Water Pollution.

Following economical priorities, Man and Water underlines the problems of the agricultural community which suffers from water shortage, while these problems are not mentioned in Sink or Swim.
In all cases in which chemical water tests are done, the 'black box' approach is taken, because students have not got the necessary background in chemistry.

The problem of thermal water pollution is dealt with only in Man and the Environment.

In Problems of Water Pollution students work only with data, which they have collected themselves. In Man and the Environment they use data from the literature. Although the social science unit Shoreline-Management contains no investigations of water, it includes surprisingly many science elements, which are used in the deliberations on water pollution and its prevention.

It would be interesting to know how, in practice, these approaches are handled by teachers and students.

Student self-evaluation is most developed in Problems of Water Pollution, where 'control steps' are used for this purpose. Self-evaluative questions on the content, but not on the functioning of the working group, are included also in Man an the Environment (as 'mastery items') and in Man and Water (as programmed text).

Chapter 4

STUDENT ACTIVITIES AND METHODS

4.1. Starting points - motivacion

Before we go from the contents and the format of the curriculum units to a comparison of the ways, in which they use different activities and methods, we shall analyze how the units start - how they handle the problem of initial motivation.

"Shoreline Management" starts with a direct involvement of the students in a board game, in which a concrete situation, disguised as the imaginary Walrus bay is simulated. While playing, the students are confronted with all the major problems of an area, which most know from personal experience, although the real name of the area is never used. The insights gained lead later to a deeper analysis of the problems and to planning efforts. Justifying the use of this game as introductory activity, the Operator's Manual (p.2) explains:

> "Students are almost always surprised to discover that the hypothetical region called Walrus is really Kaneohe Bay on Oahu's windward side, and that the hypothetical development problems they have been grappling with are

> issues of real concern to different interest groups in Hawaii. Because this realisation usually sparks student interest in the problems and solutions of Hawaii's shoreline and ocean, the Curriculum Research and Development Group of the University of Hawaii (to which the project belongs, A.B.) uses the Walrus approach as an introductory exercise to marine social studies".

In the IPN unit "Problems of Water Pollution" too, a case study is used to introduce students into the social controversy connected with water pollution. But this time fictitious Kleinhausen is the locus of the drama. In this town a class of students, lead by their biology teacher, Frau Holzmann, is investigating the city's water pollution problems.

How they do it is shown in a cartoon film, "Water and the Community" which was prepared especially for this unit. After viewing this film, which is accompanied by a spoken commentary, students are asked: "How is the water situation in our own community?"and "How could we find out?"

To balance the social studies side with aspects from the natural sciences, a second film, "Polluted Water", was prepared. It emphasizes the importance of water for all organisms and for Man specially, and introduces the health hazards connected with polluted water. Some main sources of pollution are referred to.

These two films serve as pre-information which students need to choose the topic they want to work on.

The project suggests also a "pre-phase", which seems less motivating. The teacher's guide suggests that students start to collect materials already two or three weeks before they begin to study the water pollution unit and that they exhibit this collection. Teachers and students are not advised how they should go about, without prior discussion, what should be collected and why. This pre-phase suggestion also stands in contrast to later admonishments that community surveys and actions should be planned very carefully. School trials could show if the films, without this pre-phase, and before the class

discussion on "instruction about the instructions", (in which the learning strategies are introduced) do not have a more powerful motivational effect.

The other three projects reviewed here do not start with a "real" or a fictitious case study. They prefer to start with activities, focused on the student's close environment.

In "Man and the Environment", the student text on "Man affects the environment" (p. 253) begins:

> "Would you be in favor of a highway being built that required your house to be torn down?"

and with other examples of clashes between development and peronal interests. A full page photograph shows a sign "Danger - Water Polluted - No swimming"!

After introducing the term "pollution" the text goes on (p. 255):

> "Pollution problems are usually blamed on industries and the needs of large cities. But most citizens do not think they personally pollute their own envrionment, at least not seriously. Is this so? Or ... do you add to the mess that makes your environment less beautiful and more deadly?"

After this dramatic appeal and some more examples of pollution caused by household articles, students are told to think about an experiment they would like to do to discover how common household products affect living things.

"Man and Water", like "Problems of Water Pollution", begins systematically with an account of various environmental factors and then asks students to prepare two lists of environmental components which they like or dislike. Also the Teacher's Guide (p.14) urges to consider what -

> "are the relevant and significant things in the near life environment"

and to -

> "emphasize already in the first lesson the possible 'contradictions' between different needs of the individual and society. At the same time one can point out ways, in which the imaginary gap between the two can be diminished".

So the whole message is spilt out already in the introductory talk. The Teacher's Guide is quite concerned about the teacher's role ("What is our answer as teachers? ...Should we not - as teachers - suggest positive solutions?") and it is so occupied with the message, that the question of enhancing student motivation does not come up in the suggestions for the introductory lesson. Some trial teachers are reported to have visited with their students factories to inquire how it disposes its sewage. This activity is given as example how "to foster the awareness for puplic responsibility" and not how to create motivation. This does not mean that the project team was unaware of the need to arouse student motivation. Yet because of the pre-occupation with the social message, the latter seems to have been made more explicit.

Similar to other projects, "Sink or Swim" starts with a systematical overview on the uses of water. In order to motivate students to read, the student text makes intensive use of functional photographs (like "Man and the Environment"). Pictures of soft drinks, a cooling tower, a sailing harbour and a hardly identifiable steel work are intented to be "starters" for a list on the ways in which we make use of water. After students "translate" the information given in their pictures into a list, they are asked to find other uses of water and to estimate the amount of water used in their home.

4.2. Laboratory Investigations

4.2.1. Categories of laboratory investigations

In the curricula reviewed in this study we can find three categories of laboratory investigations:

1. Experiments set up to validate or reject a hypothesis, which was formulated before devising the experiment.
2. Controlled experiments, in which the effect of an isolated factor on another is observed (without hypothesis formulation).

3. Quantitative or qualitative tests without controls.

These categories are not always clear cut. Sometimes at the end of a survey a suggestion is made to students to go on and formulate a hypothesis, which they might, then, test in a controlled experiment.In such a case the investigation was categorised according to the principal description of the activity, without taking in account follow-up questions or suggestions made in the teacher's guide.

It is interesting to note that hypothesizing , as mental process which precedes and directs the planning of data collection, is emphasized in the units with strong social science elements. There, it is usually called "speculating", but the texts make it clear that they mean hypothesizing on the basis of an educated guess. "Shoreline Management" uses both terms - speculating and hypothesizing - as synonyms, but since the hypotheses are tested rather through analysis of documents (in the social science methodology) and no experiments are performed, we shall come back to the way "Shoreline Management" treats the testing of hypothesis when we shall discuss data analyses. (Section 4.4.).

In "Problems of Water Pollution" the term "speculation" is used in a less formal meaning than the usual "hypothesizing". The first text in the Group Guidelines to Topic 2 begins (p.15):

"What is this topic about?"	What has to be done in this topic?
(1) First one can "speculate" freely. Is the water dirty or clean? Who then might be that "devil" who threw the "trash" into it?	In the groups or in the whole class we coliect our supposi-tions and write them down. In the process of our work, we shall check these suppositions.
(2) One can measure pollu-tions in different ways. One of them is to deter-mine the oxygen content ...	Now we experiment ... This is done so that suppositions can be checked ...

Students are reminded that always a control experiment should be set up (p.23).

In the teacher's guide (p.25) 'hypothesis' is used as synonym to 'speculation'. A similar approach can be found in "Man and Water" where the students' text (p.27) gives detailed instructions how to set up an experiment to explore the effect of animals and plants on the pH of water. Students are asked what they expect will happen in each of the aquaria, and then to check if their hypothesis was right.

In the final experiment in "Man and Water" students are reminded that a control is necessary, but no hypotheses are formulated. That would be artificial since this experiment is actually a demonstration of the effects of pollutants which were already discussed in the student text.

Similarly in "Sink or Swim" hypothesis validation is either described without using the term "hypothesis" or disregarded. In the hay infusion experiment the question is asked (p.11):

> "Is it possible that, in some way, sewage kills fish by reducing the amount of oxygen in the water, rather than by poisoning them? In fact, does sewage pollution result in less oxygen?
>
> You can investigate this by setting up samples of water polluted by decaying plant and animal (organic) matter which is similar to sewage, and finding out if there is much dissolved oxygen in them. You can use a dye called methylene blue. In water it will become colourless if no dissolved oxygen is present. If plenty of dissolved oxygen is present the blue colour will remain".

Here two stages of hypothesizing are described, in applied form, but not "called by their name": a question is asked and an "if - then" deduction is made.

In the second experiment and last laboratory investigation suggested to learners of "Sink of Swim", these are asked (p.37):

> "How could you set up a simple experiment to find out how effective chlorine or compounds which can release chlorine are in killing bacteria?"

In this case the emphasis is on the technique of experimentation and the hypothesis seems to be self-evident. Also in the only laboratory experiment in "Man and the Environment" the emphasis is on the technical side - how to plan, execute an summarize an experiment on possible effects of a household article on a living organism. The student text (p.257) hints that one specific effect should be investigated and mentions controls - but hypothesizing is ignored.

The other laboratory investigation in "Sink or Swim" belongs to the last category - quantitative tests. These are different from experiments in two respects. In the first, one is interested to investigate a given situation, as one finds it and to compare it to similar situations, but no hypothesis is developed and therefore also no crucial control treatment can be set up. For instance in "Sink or Swim" and "Man and Water" different water samples are tested for the presence of bacteria and by comparing the results conclusions are drawn on the apparent differences between the samples.

In none of the curricula units such methodological differences are pointed out explicitly to the students.

4.2.2. Difficulties in setting up laboratory investigations

Two major types of difficulties have often to be dealt with, when laboratory investigations are set up in environmental education programmes. Students might find it difficult:

1. To understand the principles behind tests;
2. To handle sophisticated equiment.

The titrations made in water quality tests are based on a series of chemical reactions, which students in lower secondary schools have not (yet) learned. The same holds true for the understanding of the logarithmic notation of pH. Sometimes measures like the Bio-chemical Oxygen Demand are used and the authors have to decide if they can and should explain the concept thoroughly.

Environmental curriculum projects seem to approach this problem in four ways:

a) If the understanding of the concept is deemed to be of real importance, special exercises are written, e.g. in "Problems of Water Pollution" the term Bio-chemical Oxygen Demand (BOD) is explained in the text (p.27 - 31). After quantitative tests are made, using the ready made Hach-Test Kit "Dissolved Oxygen", students determine the Bio-chemical Oxygen Demand of the water samples they had taken. These BOD determinations are then used as one of the factors to assess the degree of pollution in the investigated stream (p.32).

b) Sometimes a technical term like BOD is explained only in the teacher's guide and if the teacher wants to develop this test for demonstration or exercise purposes, he finds in the teacher's guide references to standard methods. This approach to BOD is taken by "Sink or Swim" (Teacher's Guide, p.20).

c) A third possibility, chosen in the case of Oxygen Demand by "Man and the Environment" is to use the term briefly in the students' text, without doing laboratory tests. Therefore details on standard practices like keeping the sample for fixed time at a standard temperature are even not mentioned and the test (p.295) begins with the words: "Chemists have a test to measure ...". The few lines on Chemical Oxygen Demand (COD) in the student text concentrate on giving the rule that the higher the chemical oxygen demand of a water, the more oxygen is used up. Then students are expected to find patterns in a table, in which maximum, minimum and average values of COD, measured in three areas of Lake Erie are given. No comment is added in the teacher's edition.
In this case the authors took actually the "black box" approach, in which an instrument or a term are used, without understanding how the instrument works or how exactly the term is defined technically. All projects use this approach in certain cases. We have seen that in "Problems of Water Pollution" tests on dissolved oxygen play a major role and gave the name to one of the four main topics. But the technique of the test is handled as black box. Instructions are often (e.g. p.19-21):

> "Add DO I, add DO II... fill up with the yellow solution ... add PAO solution",

without explaining the chemical composition of each solution.
A similar approach is taken by "Man and Water" in its oxygen test. The student text (p.30-33) refers to four reagents by consecutive numbers. In what seems to be

a compromise with chemical usage, chemical notations ($MnSO_4$, KJ-KOH, etc) are given in the text but it is clear that students do not know how to read a formula like $Na_2S_2O_3$ and are actually not expected to do this, because the text goes on in the style of -

"Add to the dark-blue liquid drops from bottle No.4... until the colour disappears".

A full chemical explanation is given in the Teacher's Guide. "Man and Water" treats also pH in a similar "black box" approach. The term is often used as scale for acidity - in a similar way the weatherman on televison speaks about air pressure, but it is not deemed necessary that the reader (or viewer) knows the exact definition of the term.

d) Other curriculum development teams might find the first approach (full explanation to students) too difficult, or not worthwhile, the second approach (leaving the problem to the teacher) not workable or unfair and the black box approach too superficial. Therefore they would rather not use a concept at all and not develop a laboratory investigation, when this would imply performing technical steps without understanding them fully.

Also "Shoreline Management" does not mention the concept of Biochemical Oxygen Demand - but apparently for a different reason. Since it is a social studies unit without experiments, the emphasis is on the socio-economic reactions of various interest groups. Therefore in the Walrus game one quantitative factor of water deterioration (a black box called "pollution factor K") is used without going into details on which measurements this factor is based.

Of course no rules can be drawn up, how a curriculum development team should act in its specific educational situation. The categories and examples analysed here can only serve as checkpoints for the options open to curriculum developers.

The second major decision curriculum workers have to make when divising laboratory investigation is: How to overcome the difficulties students have in handling equipment, e.g. microscopes or living organisms.

The developers of the units under review tackled this problem in different ways. "Man and the Environment" (like "Problems of Water Pollution" and the social studies unit "Shoreline

Management") does not include microscopic investigations in the chapter on water pollution, but microscopes are used in other parts of this life science programme. A special appendix "observing with the microscope" is printed in the student's text. It is based on annotated photographs, which show step by step how to prepare the slides, how to carry a microscope and how to use it.

"Sink or Swim" again leaves it to the teacher to plan laboratory observations if he so wishes. Different topics are suggested, e.g.

> "Simple temporary preparations obtained by placing a sample of water on a microscope slide can be examined. Organisms present may be identified, at least in their main group..."
>
> (Teacher's Guide, p.15)

Then a useful source, suitable also for students, is given as reference. Other suggestions are: To connect the discovery of protozoans with the presence of the bacteria, which serve as their food. This could be developed into an elementary dicussion of a food chain.

In "Man and Water" no microscopic work is suggested in neither the student text nor the Teacher's Guide, although 9th grade biology students are supposed to have been taught how to use a microscope. No reason is given by the team. Perhaps the preoccupation of the team members with the chemical side and the affective objectives of water pollution had something to do with the non-inclusion of microscopic work. Only the later published Teacher's Guide 3 (p.17) on the "Excursion along a Stream", which was developed by two biologists, suggests that plancton samples might be preserved in formalin for microscopic inspection in the classroom, or portable microscopes might be used on the spot.

In "Problems of Water Pollution" a topic involving microscopic work was first planned, but later abandoned, because of the difficulties students had in identifying plancton bioindicators.

Handling living organisms is another problem which is not always recognised as such by curriculum developers. Teachers in England seem to be specially concerned about handling plants and animals. A specific project-Educational Use of Living Organisms (EULO) has produced booklets for the use of teachers (WRAY, 1974). Also in "Sink or Swim" attention is given to the protection of organisms. Students are told (p.23) to:

> "make a note of the animals you have collected, then return them to the stream".

In "Man and Water" and "Problems of Water Pollution" samples of living organisms are transported to the school for further examination. The Group Guidelines to Topic 1, in "Problem of Water Pollution" give detailed instructions how to catch and handle the organisms, but nothing is said on the subject of protected species, how many specimens of a species should be taken for further investigation and if they should be returned to the stream after they are no longer needed in school.

In the Teacher's Guide on Excursion along a Stream (p.25) of "Man and Water",teachers are reminded:

> "Be punctilious not to harm protected animals (e.g. tritons). In case you have caught some, look at them, but then you must return them into the stream.
>
> Also from non-protected animals only a few should be taken, for two reasons:
>
> 1 - their conservation
>
> 2 - crowding animals into one bucket can kill them..."

A somewhat different problem exists, when animal experiments are set up. Obviously in this case no protected species are used, but the ethical question is raised, if students should be encouraged to experiment with animals which might be harmed during the investigation.

> In "Man and Water" a final experiment is set up "to investigate the effect of various materials which get into the water on organisms living in it".
>
> (Student Text, p.58)

In spite of this statement only tests on the water quality are suggested and not observations on the behaviour of the organisms. But the Teacher's Guide (p.67) is conscious of the fact that students might see the experimental animals - Gambusia - die or being harmed. Therefore it warns:

> "One must take in account that by adding detergents (into the aquarium as suggested by the student text A.B.),the gills of the fish are harmed immediately after the first contact. Therefore a small net and a bucket with clean water should be handy to save the fish immediately after their first contact with the detergent. The detergent causes the capillaries in the gill to blast and red colour will appear.
>
> If the killing of animals in the laboratory is felt to be uneducational, then it is best not to demonstrate the effect of detergents on organisms living in water or to do this in an aquarium without fish".

"Man and the Environment" suggest that students should set up an experiment to investigate the effect of a common household product e.g. a weed killer, detergents or bleach on an organism. Among the suggestions for possible organisms are i.a. crayfish, "young local fish" and gold fish. The only restriction in the teacher's annotations (p.259) is:

> "Experiments which intentionally end in the death of an organism, especially a vertebrate, should be avoided".

4.3. Outdoor observations and surveys

One would certainly expect environmental programmes to encourage first hand outdoor observations, and to give students a chance to experience the environment, which they study. But outdoor activities provide not only affective gain. They are as important to learn techniques of ecological investigations as they are to understand the limits of experimentation in science. The methodology of ecological surveys is in many ways similar to data collection in a laboratory experiment, although the techniques are different. Usually different equipment is used and measuring is not as

convenient as in the laboratory. But perhaps the most fundamental difference between field observations and experiments is, that only in the latter factors are manipulated.

In survey work and in natural-historical studies one cannot experiment. In surveys one is interested to collect data on the phenomena, as one can perceive them, without trying to isolate factors as done in a controlled experiment. The same is true about collecting evidence to substantiate hypotheses and theories about the past. The experiments of Urey and Miller can show that their theory about the origin of organic matter is feasible, but not that it really happend this way.

This difference between controlled experimenting and collecting evidence on historical speculations is by no means trivial. It is often not spelled out in science courses. The result is that many students believe that evolution is "a fact" which was "proven" and not only a theory with a lot of evidence of non-experimental character to substantiate it. When Experimenting is written with a capital E, as it is in the New Science curricula, students come easily to believe that every question can be investigated experimentally, given time and opportunity. Field surveys, speculations on phenomena observed outdoors, which cannot be brought for experimentation into the laboratory, can serve as an important tool to bring home to students these basic differences in scientific investigations.

Most curricula, including those reviewed here and those which encourage students to collect data and to test hypotheses, do not point out explicitly the difference between experimentation and testing speculations on natural history. Questions of natural philosophy and of choices of methodology are apparently not deemed fit to be included in courses offered in secondary schools.

Three of the five units under review encourage field investigations and especially water pollution surveys. Field work is

most prominent in "Problems of Water Pollution", where most student activities are directed to the collection of data outside schools - either on the pollution in water or on opinions in the community. In this project methodologies are discussed intensively in the student's text. Hints are given how to check what difficulties they are likely to encounter. This is done specially in form of "control steps" (see section 3.5.).

In "Man and Water" the excursion along a stream is surely an important part of the unit. But because local conditions vary, much of the details how to conduct field investigations are left to a special teacher's guide subtitled "Excursion along the stream" (see section 3.3.).

In both curricula special water pollution "Kits" were developed, which can be used by students to do various water tests without understanding the chemistry behind the reactions. Besides physical, chemical and bacteriological tests, pollution assessments are made by looking for indicator organisms. In "Problems of Water Pollution" also iron sulphide deposits are used for the same purpose.

In "Sink or Swim" an animal indicator survey is the only field activity described in the student's text. Earlier experience in Britain had shown that students can do these assessments quite accurately without prior training (see section 2.1.). On chemical tests the Teacher's Guide (p.20-21) states:

> "Quantitative methods of measuring oxygen concentrations are available, but all accurate chemical methods are complex... Oxygen meters are available, but these are costly..."
>
> "Analysis of river water for all possible types of pollutants down to traces of complex chemicals is both time-consuming and requires expensive equipment".

It seems that for these reasons "Sink or Swim" prefers to let students work on ready data on the pollution of River Thames.

Also "Man and the Environment" does not assume that students collect their own data on the local water pollution situation. In this unit the emphasis is on looking for patterns in the data presented in a case study on Lake Erie.

In "Shoreline Management" the problem of water pollution surveys does not come up because practical investigations are assumed to have been made when students studied the Marine Science Program.(1)

Two of the water pollution units reviewed ask students to assess the amount of water used in their home. "Sink or Swim" suggest a method based on actual measurements. In "Man and Water" students get this information from the water bill.

In "Problems of Water Pollution" the emphasis is on the community as a whole and not on the student and his family. The questions "What does the community do about water Pollution?" and "What do people think about it?" take up about as much time and effort as the limnological investigations.

This project emphasizes that in the collection of data, there exists a difference between natural phenomena and social opinions:

> "Much of what can be thought over quietly in school, does not work out so nicely outside... We mean that students could find obstacles when they look for information and opinions outside school. Yet if one is conscious of possible difficulties, one can try to counter them".
>
> (Group Guideline to Topic 4,p.28)

Then the student text goes on the point out five difficulties and to suggest "tactics" how to overcome them.

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(1) But the Marine Social Studies Project got earlier on the way, while the Science units on water pollution have not yet been developed, when the study was done. The Marine Social Studies too are still in a trial stage. As pointed out earlier, both projects are well coordinated in their planning.

All five envisaged difficulties are about negative reactions students might get from adults when these are interviewed by school children:

"What do students know about water pollution?"

"Here comes a student in jeans to the mayor..."

"Adults get suspicious if somebody without official task, somebody without legitimation, asks them". (The solution suggested is an "Enquiry Card" signed by the teacher), or -

"I worked already 8 hours and now students come... Can the teacher not tell them the facts?"

"Problems of Water Pollution" makes it also clear that different people may represent different interests and therefore also voice their opinion accordingly.

4.4. Analysis of Data and Critical Reading

The emphasis put on analysis of data seems to stand in an inverse proportion to the place data collection takes up in a curriculum unit. On the one end of the spectrum one can find Shoreline Management and Man and the Environment (both without out-door investigations). On the other end are Problems of Water Pollution and Man and Water, where data collection is more emphasized than critical analysis.

In Shoreline Management students are presented with data on a case study (Kaneohe Bay) in form of graphs and of historical accounts. Students are expected to summarize changes over time from these and any other sources they can find, and to identify different aspects of changes in demography, lifestyle, land and marine environment. For this purpose they use four charts. Then they are asked to consider whether any of the changes in the four categories are related to each other, and to hypothesize on likely causal relations. For this purpose formal cause/effect notations (using arrows) and 'if - then' statements are introduced. Students test their hypotheses by looking for further evidence, mainly statements made by experts. They

are asked to write down, if the evidence supports or rejects the speculated causal relationship and if it does so strongly or weakly.

In Shoreline Management students are not warned that articles in daily papers (which are cited in the student text), even when written by acknowledged experts, might contain unbalanced opinions, not necessarily based on facts.

The other water pollution units under review do not explain explicitly the different steps in hypothesis forming and testing.

In Man and the Environment the emphasis is put on the critical search for patterns and relevance in the data. Students should learn to differentiate between relevant and irrelevant data, even when the latter are assumed to be valid by themselves. The annotations in the teachers' edition (p.266) warn:

> "All the data is valid as indicated by its sources, but not all of it is relevant to this particular problem. This is the way things are in real life."

In this project,data are presented concisely in the form of tables, graphs and maps, but no original papers are cited. Some graphs contain extrapolations, but the authors did not differentiate, neither in signs nor in a verbal explanation, which part of the graph is based on measured data and which is extrapolated. Such a treatment of extrapolation can easily lead students to believe that the predictive value of the extrapolation in the graph is as reliable as the representation of veryfied data from the past.

In Sink or Swim, data collection and analysis seem to be best balanced. Some data are collected by students, others are presented ready made. In an extrapolated graph on water pollution the title of the graph states which part is based on measurements and which is estimated, but this difference is not emphasized by using a broken line for the extrapolated part or by drawing students' attention to the fundamental

differences between interpolation and extrapolation.

In Sink or Swim (as in Shoreline Management) students are asked to read parts from an original research report and to answer slightly critical questions, but no contradictory statements are presented.

The concept of change over time is introduced in Sink or Swim by presenting students with a graph showing the percentage of oxygen saturation in River Thames, 1930-39, 1954, 1969. The analysis of the data shows that the situation has improved in the last period.

Neither Problems of Water Pollution nor Man and Water use case studies to discuss the validity and relevance of data, nor do they present original or rewritten research reports in order to train students in analytical reading.[1] Students are expected to analyse and discuss the data of their own investigation. As in Sink or Swim, clippings from daily papers are reproduced also in Man and Water, but no critical questions are asked, even when the student text cites conclusions on controversial issues (e.g. danger level of nitrates in ground water) or declares Haifa bay as 'dying'.

Man and the Environment emphasizes that the outcry 'Lake Erie is dead' could well be pre-mature and should teach us to be careful in phrasing conclusions.

Problems of Water Pollution use sources like laws and expert statements, some of which include prognoses for future water demands. No contradictory expert opinions are cited, because the team believed that these differ only quantitatively and do not allow for a relevant discussion.

Although some of the curriculum units (e.g. Man and the Environment and Problems of Water Pollution) emphasize that

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[1] Only in the final exercises of Man and Water some fictitious data, adapted from Man and the Environment, are used.

different interests and opinions exist, none of them seems to think it necessary or feasible to plan special activities to teach students how to distinguish between facts, interpretations, wishful thinking and propaganda.

In Problem of Water Pollution students meature pollution parameters and ask people in their community to give their views on the seriousness of the situation. These two concurrent activities were planned to enable students to relate measured data to opinions held by people with different interests.

4.5. Socio-cultural and Historical Aspects

The term 'environmental' was often used as a popular synomym for 'ecological', but it seems that more and more curricula are becoming increasingly concerned also about the socio-cultural environment of the students and the events of the past, which contribute to the present state of affairs.

Historical episodes are used in environmental and science programmes for two purposes: to bring students nearer to their cultural heritage and to show how science developed.

The curriculum unit which can go furthest into the past is "Man and Water". The student text starts with a biblical quotation:

> "And the men of the city said unto Elisha: Behold the situation of this city is pleasant as my Lord seeth; but the water is naught and the ground barren. And he said: Bring me a new cruse and put salt therein. And they brought it to him. And he went forth unto the spring of the water and cast the salt in there, and said: I have healed these water; there shall not be from thence any more death or barren land."
>
> (Kings II, ch.2, v.19-22)

This quotation does not only stand as motto. One of the questions in the student text refers to this and other quotations from traditional sources, asking students: "What were the criteria for good water in ancient time?" and "What were the methods of water cleaning?".

The question if polluted water could be 'healed' by using salt, as did Elisha, is dealt with in the teacher's guide and an experiment is suggested, in which the flocculation effect of salt and its osmotic effect on bacteria can be shown.

The chapter on 'The Treatment of Drinking Water' in Man and Water pivots around five archeological photos which show water collection methods from the Nabbatean and Byzantine periods. Students are asked to find out the differences in the water supply problems between then and now.

The factor of cultural heritage is also emphasized in the two American curricula units under review. As we have seen (see section 2.2.5.) the whole Marine Social Study Project, of which "Shoreline Management" is part, was strongly influenced by the idea that pollution and the destruction of coral reefs came to Hawaii only with the advance of Western technology. The first activity in Why Shoreline Management is 'A Little History of Kaneohe Bay'. It starts with an account of life in pre-historic Hawaii (that is pre-Captain Cook). Students are told that the old Hawaiians used a system of terraces and dikes which trapped stream run-off from the mountains. To prevent the water from running off into the bay they built ponds.

> "During the many years the Hawaiians lived on the shores of Kaneohe Bay they lived in harmony with the land and the sea."

The historical account is then used to let students "visualize the types of change which occured and who or what was involved in these changes."(See section 4.4.).

In "Man and the Environment" the major part of Investigation 21 - 'What is the price of progress?' - is taken up by a game (287-301), which -

> "...Takes place in Central City, in the north-eastern United States. The game begins in 1885 and runs years into the future...
> Central City ist industrial America."

In the game there are five periods, each covering 20 years of history. The student's text gives a short historical account of Central City's development from 1885 - now. The emphasis is on thermal pollution of Central City's river, but wider aspects of industrialization are also introduced. (See section 4.6. for details on the game).

In "Sink or Swim" no 'good old times are described. An excerpt from a discussion held by a Select Committee and cartoons from the 1850's show that River Thames was then already polluted and stank (pp 16-17).

One of the most impressive chapters in Sink or Swim is on water pollution and disease (pp24-29). It focuses on the cholera outbreak of the 1850's. Contemporary drawings show the poor in Whitechapel, a girl who died of cholera, burning clothes and burning tar in the streets. Students are asked to examine the pictures and to think how these conditions arose and how people in those days believed cholera was spread. The teachers' guide explains (p 24):

> "It was the appearance in Britain of this disease which first brought the terrible living conditions of the city poor to the notice of the public, and resulted in what was known as the 'Sanitary Movement'..."

So far the emphasis in the historical episodes cited was on the socio-cultural issues and directly related to the history of the respective nations and their socio-cultural developments. In Sink or Swim the cholera epidemic of the 1850's is also the starting point for a case study typical for the history of science - John SNOW's survey which showed that cholera was carried by infested water. Parts of SNOW's original map of the cholera stricken area of Soho and of his research report are reprinted in the student text. Further documents, maps and drawings are provided in the teacher's guide.

A short account of the discovery of the connection between cholera and water supply appears also in "Man and Water", but only the main facts are presented briefly, without historical pictures and without student questions or

activities.

In "Problems of Water Pollution" no historical materials was used. No attempt was made to connect the water pollution issues with the heritage of the past or with the history of science. The texts which are dedicated to social studies deal solely with contemporary questions.

4.6. Games and Simulations

Games and simulations are used in 'New Social Science' curricula for similar purposes for which experiments are often made in the study of the natural sciences: they motivate und activate students, visualize problems and let students re-discover cause-effect relationships and principles. To a smaller extend than experiments simulations can show students how 'real scientists' proceed in their work.

When science curricula projects, and especially those in the life sciences, began to emphasize the impact of science and technology on society and the environment, they adopted also games and simulations as legitimate learning activities.

Among the environmental curriculum units discussed here four use either a game or a simulation (or a combination of both). These simulation games range - in form - from Monopoly-type board games to role-playing without a luck factor, in time - from a reconstruction of the past over solving a contemporary problem to planning the future, and in 'reality' - from fiction to a careful simulation of a specific case.

Walrus-Hawaii (see section 3.1. for the adaptation process) is a simulation game which is played on a board. It presents incentives like economical, political and environmental gain - distinct characteristics of a game.

Its objectives and rationale are defined in the Operator's Manual (1-2):

> "Walrus-Hawaii ... is designed to show the relationship between urban growth in the Kaneohe Bay region and water pollution in its streams, bays and ocean. A simulation

> allows participants to experience a 'real world' situation, with all its attendant complexities, within the controlled temporal and spatial limits of a game ... Successful simulation games include a variety of group positions on a particular issue and are structured so that an individual player can realize his goals only by working for those of his group."

In Walrus-Hawaii the student participants are grouped according to five representative economic interests (see section 3.4.). These groups are economically and politically active and -

> "try to balance the alternative and often conflicting goals of financial profit, community planning and environmental preservation. Several rounds of the game are usually played before the students realize the necessity of planning in order to avoid environmental degradation of the bay, as a consequence of their development of the area. When this awareness occurs, the teacher or director stops the game and begins to debrief it with the class."

Because of its motivational effect, playing Walrus was chosen as the opening activity in Shoreline Management (see section 4.1.).

> "The game allows students ... to draw from their gaming experience as they move into 'real world' problems and theoretical concepts during the remainder of the course."
>
> (Operator's Manual, 2).

In contrast to the other simulations and games used in the curriculum units under review, Walrus is the only one which uses actual data on land and water use in a certain area.

Players may make decisions and play the game in any manner they wish as long as they stay within the flexible rule of the game. Man-made laws (in contrast to natural laws and their consequences) can be changed by an elaborate political process based on voting power and influence,which in turn can 'purchase' more voting power.

'Natural laws' may be changed only if a player can reasonably show that another natural law is more realistic and should therefore be made part of the game.

Both man-made and natural laws stated in the rules of play are grouped according to politics, land use, finance, water use and sewage.

There is no single goal which all players or teams must seek to win. Obvious goals could be -

> "acquiring money, land or political power; or developing cities, or preserving the natural environment."
>
> (Participant's Guide,p.1)

The full rules of the game are quite complex and players are not expected to master them. As is 'real life' they are compiled in a codex for reference. The different steps of play are made easier to understand by the use of forms. The characteristics of a game (board, chips) and publications of the 'Wal-Press' add to the playfulness of the simulation, but there is no individual winner and nearly no dependence on chance factors.

"Man and the Environment" makes the widest use of games and simulations in its chapters on water pollution. Two board games (The Thermal Pollution Game, and The Pollution Game) and a structured simulation (The Atomic Power Plant Controversy) are used.

The Thermal Pollution Game asks the question "How did the rivers get hot?". It is about the development of Central City, which stands for industrial America. In this game the board is made up of four concentric rings, each representing a 20 year period in the development of the city. Each ring is devided into sectors, according to the industries which existed at the time. Students 'repeat history' by going through the four periods. They are told that "in each period you can make a fortune and affect the rivers". In each round they read a short description on the development of Central City during the last twenty years.

Initial wealth is alloted by tossing a die. Players can

invest their money in the various economic branches existing at the time. In each following round students toss the die once more and an 'income and temperature index' tells them how many times their income increased, but also by how many degrees the temperature of Central City's rivers went up. The game is so structured that high incomes are coupled with high thermal pollution and therefore a conflict between financial gain and environmental conservation is created. A coloured chart shows how organisms are affected by the thermal pollution index. Students are told (p. 295) that -

> "Any player concerned about the effects of thermal pollution can try to do something about it. In the next round he can invest money in industries that he thinks won't add a lot of heat to the water."

At the end of the fourth round (1945 - now) the player with most wealth accrued is the winner. The fifth round (now - 20 years in the future) will be played only after'solving the atomic power plant controversy .

At the end of Man and the Environment the final Pollution Game is played. It is also a Monopoly-type game, but this time it is not enough for players to accrue wealth to become the winner, although the individual winner is still the player accumulating the largest amount of money. The game is designed to be played simultaneously by competing teams of four players, although it will work if there is only one set of the game and one team of players. Each team needs a separate board to play.

As in The Thermal Pollution Game personal wealth brings about water and air pollution. When these are not checked in time, the air pollution index and the water pollution index will reach a lethal level and the group will not be able to survive and they all lose.

As in Monopoly each player collects rents or fees from other players that land on his property and there are chance cards. But any player can also call for an election. To do so he hands in to the banker one of his two election cards and

chooses one of ten printed proposals how to reduce the pollution. Each proposal effects the property-owning players differently and therefore a majority vote is necessary to pass a proposal.

At the end of a fixed time (one or two class periods) the team that has the lowest air and water pollution index wins. The individual winner in the class is the player who has most money.

Apparently influenced by The Pollution Game, the "Man and Water" project has developed a similar game called Caution-Pollution! The game deals with the impact of water and air pollution on Lake Kinneret (JOEL, 1977), a geographical area well known to students and the focal point of many environmental debates in Israel. Therefore the issues dealt with in the game look more 'real' than in a game on a fictitious lake.

Role playing in a simulated situation can be structured, based on data, or unstructured with maximum freedom for participants to create not only their own roles, but also to 'invent' the data. The latter is problematic, because when acting in such an unstructured simulation it is much more difficult to differentiate between 'facts', their interpretations and empty propaganda slogans.

The Atomic Power Plant Controversy in "Man and the Environment" is a role play simulation of a debate held before a State Health Board. A hearing is called to decide if the Wattson Electric Campany should be permitted to go ahead with its plan to discharge uncooled water from a new atomic power plant into Lake Serena or if there are other ways to get rid of waste heat, which could be permitted. Five students are elected to the State Health Board, the rest choose their roles from a list on the blackboard. The roles are:

Wattson Electric officials,

State Industrial Association (supports Wattson Electric strongly),

Majority and minority of the City Council (which had approved the plans in spite of opposition of the younger members),

Committee to Save Serena Lake (consisting mainly of sportsmen and conservation groups. It demands the building of a cooling tower or pond),

Friends of the Environment (opposes the building of an atomic power station strongly. They believe people should use less energy).

Each interest group receives not only a description of their roles, but also a detailed data bank which the group should use to plan its strategy. The data bank gives information on the physical characteristics of the lake and its present use. The heat problems of the existing and the planned power stations are explained and a temperature map of the lake is given. The latter can show, for instance, that an 'average' figure given by Wattson Electric is actually a bluff. Other entries are on ways to remove heat from power plants and the effect of adding heat on an aquatic community.

As usual in educational games and simulations, also The Atomic Power Plant Controversy is reviewed by the participants in a post game de-briefing.

In "Problems of Water Pollution" a less structured role play simulation is used and more emphasis is put on the artistic potentialities of such a play:

> "Who doesn't want to jump out of his skin for a while and into that of someone else? To play Mayor ...
>
> Would each participant please read once more the texts. One can then better counter (the arguments). Now it starts: the role play begins."
>
> (Group Guidelines for theme 3, p.14).

The setting is similar to the Atomic Power Plant Controversy - a public debate is held. In Problems of Water Pollution the mayor of Kleinhausen has been attacked in the press by a citizen's committee and by students for his backing of the local brewery which threatens to move to another town if it has to pay for its own sewage plant. Jobs are at stake and the mayor decides to face the public in an open discussion.

Here few briefs of the roles are used. Students are encouraged to take part in the debate as "well informed citizens who are interested in the welfare of the town".

In Kleinhausen the problem is not one of allowing an industry to expand and to pollute the water (as in Central City). The issue is: Who should pay for the water reclamation costs - the industrial plant causing the pollution or the community? Therefore neither physical nor biological data are discussed. Participants in the debate can use as resource materials:

Quite a polemic speech the mayor has made and which is reported in the Kleinhausen Journal,

A letter to the editor of the Kleinhausen Advertiser written by a school class,

The protocols of a telephone call from the mayor to the editor followed by a witten reply in the Advertiser,

The minutes of a meeting between the mayor and two directors of the brewery,

A short description of the revenues of Kleinhausen,

The most relevant laws on water pollution, annotated and explained,

Excerpts from a volume of expert statements, compiled by the press and information centre of the German Bundestag.

The backgrcund information is given partly in the group guidelines for theme 3 and partly in those of group 4.

In Kleinhausen, as in Central City, the debate ends with a majority vote.

Unlike Man and the Environment, in which the emphasis is on the biological - technical aspects, in Problems of Water Pollution also the importance of keeping records is underlined. Students are asked to write reports or use a tape recorder to prepare the minutes of the debate.

4.7. Problem Solving and Decision Making

These two terms are often used as synonyms in curricular units, but there seems to be a difference in their interpretations. 'Problem solving' refers usually to a wider range of mental activities. It certainly implies the application of previously acquired knowledge to a new situation, (category 3 in BLOOM's taxonomy of cognitive objectives, 1956). In environmental education it is normally assumed that some divergent thinking is necessary to solve 'real life' problems (even in simulated situations) and that more than one solution can be accepted, in contrast to the solution of a 'problem' in, let's say, a mathematics or physics book exercise, where a student is expected to think convergently and to come up with only one right answer.

Sometimes the term 'creative thinking' is preferred to emphasize the unique character of each solution. "Man and Water", for instance, defines one of its objectives as -

> ".. the ability to apply knowledge in new situations and to show creative thinking".
>
> (Teachers' Guide 1, p. 7)

In many environmental curricula and in the IUCNNR definition of environmental education (see section 1.1.) the term 'decision making' is used in order to underline that in the solution of real problems the analysis of the complex problem is followed by a decision, which of several alternatives should lead to an optimal solution.

This aspect of choice is emphasized in one of the objective in "Man and the Environment" (Investigation 21), according to which students should learn -

> "to willingly consider alternative solutions to the problem of waste heat disposal".
>
> (Teacher's guide, p. T70)

In many of the mastery items (see section 3.5.) in this project students are asked to solve environmental problems in a fictitious situation. Some of these mastery items were adapted by Man and Water to suit an Israeli situation.

To manage a problem-centred project means to make deliberate decisions. It is in this sense that the term 'management' is often used in the titles of problems in Man and the Enviroment and "Shoreline Management".

"Problems in Water Pollution" expect the student "to become qualified to execute an own follow-up project" (Teacher Information, p. 9), in which he has to make his own decision. In the earlier stages of their work students are asked to either vote, as an exercise, on the situation in fictitious Kleinhausen, or to decide in situations over which they have control: their own school work. The project team did not believe that "decisions" in a simulated situation can be considered as real decisions. Therefore students are not asked what they propose to do in order to solve the water pollution problems of their community (unless, of course, they choose this question as topic of their follow-up project).

In "People and Resources" (the teachers' guide to Sink or Swim) the training towards decision making is emphasized as one of the major aims of the programme:

> "to provide experiences of both the science and the art of making decisions concerned with the balance between environmental exploitation and human needs".
>
> (Teacher's Guide, p. 7)

The differentiation between the science and the art of decision making is an intersting one. It points out the main difficulty in decision making, be that in economical, political, juridictional, medical or any other field. Methods of Analysis and perhaps even the crystalization of alternatives can be taught, but taking the right decision at the right moment remains in the end an art. Computer programmes can show the decision maker some

possible outcome of a small number of alternative decisions, assuming the relative weights of all decisive factors are known and programmed (yet they never can be forseen so precisely). But decision making involves also a lot of intuition and it is not yet clear how much this can be trained.

Even if we assume that decision making is at least partly an art rather than a science, then still training in the techniques can be given, as it is to art students.

What are the techniques which are used in the water pollution units under review to train students in decision making skills? Two of the most powerful techniques, which are used more and more in managerial training centers - gaming and simulation - have been discussed in the previous section. Their value for decision making grows with the closeness to real data.

System Analysis is another technique which is widely advocated both for real and simulated situations. It is used to some extend in Shoreline Management to teach students -

> "to work with a model of human interaction with the marine environment".
>
> (Supplemental Teaching Notes, 6.10.1976)

and by Sink or Swim to find a solution how so save water in an industrial process.

In "Shoreline Management" a concise, symbolized model to generalize relationships is used. Students read the definitions of marine environment, human intervention, ecological processes, Man, and costs and benefits. Then they are asked to place the symbols for these five elements in the appropriate places in a diagram. The diagram itself consists of five empty spaces, into which the symbols have to be inserted, and arrows which connect the spaces into a system of interrelations (Marine Enviroment ⟷ Ecological Processes and Marine Environment ⟶ Cost/Benefit ⟶ Man ⟶ Human Interaction Marine Environment).

Before attempting this task, students have learned to describe cause-effect relationships with the help of arrows.

The activity following the model building exercise on man's interaction with the marine environment is a cost/benefit analysis. Non-monetary costs (e.g. actions not undertaken) and non-monetary benefits (e.g. satisfaction) are included in the analysis. Students examine five vignettes, each containing a brief description of the experiences of individuals or a family within a certain development period. The bottom of the sheet has a place to list ways in which the people involved were positively or negatively affected. It also has a place where it says 'Balance?' and students are invited to evaluate the consequences of development to these individuals and families.

Systems Analysis is used in "Sink or Swim" in connection with a practical problem students are asked to solve. A diagram (p. 41) shows the main processes involved in making potato crisps. Students are told to identify the stages in which water is used and to indicate how water is changed in each stage. Then a more elaborate system analysis diagram follows, in which the quantities of water used in each part of the process are shown. Now students are asked to design a system for manufacturing potato crisps under the following constraints:

1. The level of production must be maintained,
2. The amount of water used must be reduced by at least a third,
3. Water used in washing the potatoes is too polluted to be re-used in any other process,
4. The quality of the waste discharged into the sewer must not deteriorate.

No easy task indeed! Before attempting this task of a production engineer, students do easier exercises in problem solving and decision making. For instance, they are asked to decide what kind of land area they would look for siting a water reservoir, and what arguments other people might put up against the suggested selection.

After the potato crisp exercise students of Swim or Sink are asked to decide on questions affecting their own home or area: how to cut down water wastage in their own home and, as final exercise (p. 48):

> "You have been given the job of drawing up a policy for controlling water pollution in a particular area. Bearing in mind all the aspects which have been covered in this book, and any other factors you consider important, what policy would you decide on?"

4.8. Summary

Shoreline-Management uses as motivating introductory activity the simulation game Walrus-Hawaii and Problems of Water Pollution uses a cartoon film about Kleinhausen. Also Man and the Environment and Man and Water start with the contrasts between public and private interests. Sink or Swim, like Man and the Environment, opens with a series of photographs which catch the eye, and like Man and Water it brings quite in the beginning a list about the manifold uses of water.

The various projects suggest three categories of laboratory investigations: controlled experiments (with or without prior formulation of hypotheses) and uncontrolled tests of water probes. Formal hypothesizing is emphasized specially in the projects which have a strong social science character.

Two types of difficulties have to be overcome by projects, when they want to develop laboratory investigations: the possibility, that students don't understand chemical reactions and complicated terms, and the difficulties which arise, when a sophisticated apparatus is to be used. The first problem is solved by the projects in different ways: They prepare an elaborate explanation and exercises for students, they explain the problem in the teacher's guide and let the teacher in charge of the rest, or they use terms and equipment as 'black boxes', of which it is not assumed that the user knows what is in them. All projects, which measure oxygen in water, use this approach.

Using a microscope seems often to be a problem. Only few projects suggest microscopic activities in students' texts. But usually such suggestions can be found in teacher guides.

In spite of what could be expected from environmental education projects, they make not always sure, that students use living organisms carefully enough and keep the laws of nature conservation. In particular no rules are set, what should be done with the

animals after they have been observed. In Sink or Swim and Man and Water more attention is given to the protection of animals, in Man and the Environment much less.

Most of the reviewed curriculum units contain open air observations. They differ from each other in the methods used and in the rationale. Especially in Man and Water and in Problems of Water Pollution work on the banks of a flowing water is highly valued. In Man and Water it is the teacher who is responsible for the planning of the excuion, while Problems of Water Pollution leaves this to the student themselves.

In order to help students in this task, control steps were developed, in which students can check if they foresaw some of the difficulties they might encounter in their work. For these water investigations students of Man and Water use a specially developed kit, while those of Problems in Water Pollution use a commercially available kit. In Sink or Swim this problem too is left to the teacher, to whom technical advise is offered in the teacher's guide. In this project the analysis of data is emphasized. The two American projects work only with ready data, which have not to be collected.

There seems to exist an inverse proportion between data collection and data analysis. In Man and Water the first of these steps is emphasized, in Man and the Enviroment and in Shoreline-Management the latter. Problems of Water Pollution and Sink or Swim are more balanced.

Causal relationships and steps in the formulation of hypotheses are treated as special topics only in Shoreline-Management. In Man and the Enviroment the emphasis is put on the discovery of patterns and relevance. Extrapolations are used in this project without pointing out their problematic character. In Sink or Swim this is done at least partly. All projects expect from their students analytical and critical reading, but this is not exercised systematically.

All projects, with the exception of Problems of Water Pollution use historical sources. Man and Water goes back to biblical and archeological sources. In Man and the Environment the historical development of thermal river pollution is clad into the form of a game. Sink or Swim brings excerpts from a debate and cartoons about the pollution of River Thames 100 years ago. In this connection the history of a Cholera epidemic is used to show some aspects of the history of science.

Games and simulations are used in the New Social Science curricula like experiments in science teaching: They motivate and activate students, visualize problems and causal relationships. Shoreline-Management developed a simulation game, which is based on real data, simulates a certain case and does not use chance and luck factors. In Man and the Environment games are used even more, but here the luck factors are conspicuous. A game simulates the rise of temperature in rivers. A structured simulation gives students a chance to look at this contraversial issue, as it appears in the present time. In a concluding game the project returns to the contrasts between public and private interests. Problems of Water Pollution gives students in its simulation game much freedom in the development of the roles. They use less data and are told to participate in the debate as interested citizens and to record the proceedings.

Various projects are concerned with problem solving and decision making. Man and the Environment uses mastery items to exercise these skills. Shoreline-Management shows already in its title that decision making is part of the issue. In Problems of Water Pollution students decide how to tackle their tasks and how to plan and conduct a follow-up project. Sink or Swim differentiates between the art and the science of decision making. In this project, as in Shoreline-Management, also elements from systems analysis are used.

Chapter 5

USE OF MEDIA

5.1. Use of photographs and drawings

Photographs and drawings in school books can fulfill four functions:

1. Describe a new situation which the students have to analyze,
2. Visualize a process or set of facts which are also explained verbally in the text,
3. Make a page easier and more attractive to read, without contributing substantially to the understanding of the text,
4. Motivate or deter from doing something, according to the message contained in the illustration.

The first two functions serve mainly intellectual purposes, the latter two affective objectives. Sometimes pictures are used to let students identify with the 'hero' of the story. In such a case he should appear so as to arouse sympathy. When children are pictured as 'small kiddies', adolescent pupils might find these pictures childish and the outcome might be opposite to the planned effect. (BLUM, 1972).

When developing countries adapted new curricula developed by former colonial powers to their own needs, one of the most conspicuous changes they introduced was in the physiognomy and the colour of the students pictured in the texts, so that their own students could better identify with them.

The fact that caricatures can deter from identification with the situation shown in a cartoon is used, for instance, in "Problems of Water Pollution". In some cases cartoons in the student texts show quarreling childing, and the Teachers' Information (p. 37) explains:

> "The comical element which was introduced on purpose into these drawings should create a distance between students and their problems of cooperation without stopping them from their endeavours to find a solution".

In comparisons between photographs and drawings it was found (e.g. CUPERMAN et.al., 1970) that students prefer usually photographs and that these were also more effective in transmitting a message. Children apparently prefer cartoons over other kinds of drawings (naturalistic, stylized and primitive).

Naturally, in a commercial edition photographs and drawings are more carefully chosen than in trial editions. But if prictures are to be used as media to transmit information, to develop skills, to foster positive attitudes and to arouse interests, their effectiveness should be tested not less than the text during the trials with children. Often economic considerations, but also a lower priority given to pictures than to words, can be found behind the lesser attention paid to pictures in trial editions.

"Man and the Enviroment" and "Sink or Swim" are published in commercial editions. Both make extensive use of excellent photographs and actually open their chapters on water pollution by dramatic pictures. Man and the Environment uses colour. Sink or Swim compensates this by using even more photographs. Both projects use pictures for all four functions mentioned before.

Man and the Environment does not use humouristic cartoons, Swim or Sink uses only historical ones. The quality of technical drawings is high in both projects.

"Man and Water" is available as semi-commercial edition. It uses mainly photographs as illustrations, but because of the cheap printing process their quality is sometimes poor. Such a problem does not exist when line drawings are used. The cartoons in the student text, which were taken from a bulletin of the Service for the Protection of Environmental Qaulity, are better

than most of the technical drawings. A second colour is used, but not always functionally.

In the mimeographed trial edition of "Shoreline Management" only few illustrations are used, mainly to add a visualized dimension to the verbal information. Photographs from a pictorial history are used, but their quality is so poor that part of their potential value is lost. Only in one chapter cartoons are made use of to explain cause-effect relationships.

In the trial edition of "Problems of Water Pollution" very few illustrations are used. The only photograph in the texts is a photostat of a document. As mentioned before, cartoons are used mainly when the cooperation among students within a working group is discussed in order to bring some humour into their deliberations.

5.2. Use of Audio-Visuals

Audio-Visuals can be used for the same purpose as photographs or drawings. Each of the techniques used has its advantages and disadvantages, which have to be weighed when one decides on their use.

Many projects recommend the use of films or other audio-visual materials, but only "Problems of Water Pollution" could plan and produce coloured movies tailor-made for the programme. Partly this was possible through the cooperation with a Federal German school film institute.

The two 16 mm films with sound track are used mainly to enhance motivation and to introduce the main topics. Two 8 mm silent films describe the life of indicator organisms living in streams and how to catch them. They are shown to students in preparation for the field trip and not instead of it.

In all these films, which were prepared by Problems of Water Pollution, the potentials are well used: Movement is essential, colour adds much for both motivation and the description of sites students are not able to see (if geographically remote) or are going to look for.

In order to get to know well the indicator organisms they are going to investigate, students of Problems of Water Pollution have also the opportunity to study these organisms beforehand by viewing slides.

In "Shoreline-Management" each group is given a series of laminated pictures portraying different aspects of the change process which has been at work in Kaneohe Bay. Students are asked to put the pictures in such an order that they fit together in a plausible way. In this activity the visualization of a process is coupled with the development of skills needed when telling a historical story.

Chapter 6

RECOMMENDATIONS

It cannot be the task of a comparative study like the present to judge the projects or to replace formative or summative evaluation. A review of the written materials cannot assess what is going on really in the classroom and in children's minds and hearts - and that is what counts in school instruction. It is even hard to evaluate the texts as such without detailed knowledge of the populations using them, and little is known about them. Yet when comparing five major curriculum units on a common topic, patterns emerge and gaps become apparent. In some cases projects could gain by looking at the successful use of different curriculum elements in another programme, specially when the project is still in the development stage or revising its materials. Therefore such projects or new environmental education teams might check these recommendations against their own rationale and experience and, hopefully, profit from them.

1. Enviromental education is not complete without preparing students for their future role as environmentally concious citizens in a free society. In this role they are expected to participate actively in the decision making process. Therefore, it seems useful that students understand this process and acquire skills in decision making. The most suitable means towards this objective seem to be gaming, problem-solving in simulated situations and system analysis. If developed and used in an appropriate way they can be expected to contribute to the effectiveness and the efficiency of any water pollution curriculum.

2. The various interests which clash in water pollution controversies (and in others) are usually dealt with in the curricula units to quite some extend. But 'expert' statements are accepted by the same teams without pointing out

to students that also expert opinions can be biased and should be read critically. The skills and the habit to differentiate between facts, interpretation, opinions and propaganda tricks should be fostered by carefully planned activities which focus on this problem.

3. It is relatively easy for a student to take a stand on big issues - where to build a power station, whom to support in a fictitious city, how to run the world. It is much more difficult, but also immensely more meaningful when students are asked to decide and to implement the decision how they and their families could contribute to water saving and to the prevention of water pollution. Students should be reminded constantly that water pollution is not only the problem of 'them' (the big shots), although much damage is certainly done by powerful sources outside the students' influence. Students should also be educated to contribute their personal share, even in symbolic ways, to the improvement of their own, immediate environment. The public and the personal dedications are equally necessary.

4. Environmental problems, among them water pollution, usually don't arise suddenly. They tend to have a long, accumulating history. The study of this history can bring students to understand how to-day's problems arose, what mistakes were made and how one could learn from them. Since water pollution and its prevention are very strongly connected to many isssues in applied science, the history of water pollution can serve as an excellent case study in the history of science and technology. Curricula units which omit these aspects of the water pollution complex miss an important dimension.

5. The history of many bacterial diseases can be used very effectively as case study, in which the historical aspects of water pollution are combined with the history of science in a most meaningful way.

The inclusion of a discussion of water-borne diseases in water pollution curricula is recommendable also from the point of view of health education. This educational area and its demands on the school curriculum develop often parallel to environmental education. Both have certainly much in common, but in not few cases they actually compete for the teacher's attention. Here an integrative approach could help not only curriculum developers, but even more teachers and students.

6. Water pollution is a new topic for many teachers who during their own student days might never have come across its problems and the methods used to monitor and control water pollution. Therefore curriculum units on this subject should provide teachers with relevant background knowledge. Sometimes an up-to-date, concise and not too technical source can be indicated, but unless this is readily available to teachers, also those working away from major libraries, such a reference is of no value. In most cases the preparation of special background materials for teachers is necessary, either in the form of a specially written booklet or as a collection of articles from sources teachers cannot easily reach otherwise.

7. Field work gives a headache to many otherwise good teachers and they prefer to stay in the classroom or, at most, in the laboratory. Yet what is more relevant to water pollution studies than excursions along a water? Of course the main training has to be done outdoors and not by reading guidebooks. Yet suitable means like easy but reliable identification keys, pictures and descriptions of protected organisms (not only those rated as indicators) would be useful to many teachers, but they are absent from many teachers guides of water pollution units. Teachers need advice how to choose the best spot for an investigation and how to look out for various micro-habitats which can influence the search for organisms considerably.

8. Where water pollution is not part of a structured curriculum, many teachers will be grateful for ideas how the water pollution topic could be linked with related, ecological studies. Water pollution is always connected with environmental phenomena concerning the stream, the lake or the sea as a whole. Therefore modular curriculum units should indicate what further investigations might lead to a wider understanding of the water source studied.

9. All the curriculum projects reviewed are aimed at an unselective population of students with mixed abilities. Yet very little can be found in the teacher's guide which might help teachers to work effectively with students at different levels of intellectual development, reading and other achievements. Where the same programme is expected to be implemented in different school types (e.g. grammar, comprehensive and modern secondary schools) the problem of mixed ability teaching is augmented. At least the students' texts should be graded into different reading levels, and where students are expected to interact in groups, more advice on how to group and re-group students would be helpful.

7. Appendix

7. 1 Curriculum units reviewed extensively and the materials used in this study.

(For curricula which are discussed only briefly - see References)

Ausführlich besprochene Curriculum-Einheiten und Materialien

(Für Curricula, die in dieser Arbeit nur kurz erwähnt sind, siehe unter Literaturverzeichnis)

1. Conservation Education Project
based at the Centre for Science Education, Chelsea College, London University.
Sink or Swim? - in People and Resources series (edited by Peter Kelly).

1.1 Sink or Swim? (Student text) by John A. Barker, Sarah Hulme & Barbara Smart; Evans Brothers, London, 1975, 48 p.

1.2 People and Resources - Teacher's Guide, by John A. Barker, Paul Gardner, Joanna Howard, Sarah Hulme & Barbara Smart; Evans Brothers, London, 1975, 128 p.

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